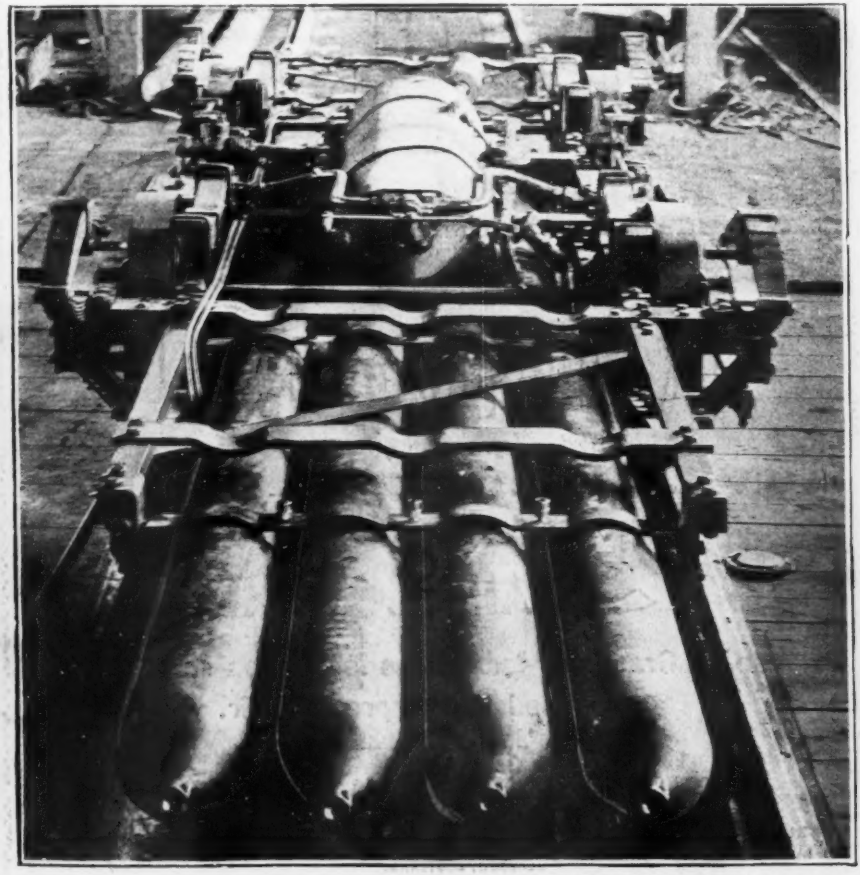
GENERAL LIBRARY,
UNIV. OF MICH.
OCT 11 1900

Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. V. NEW YORK, OCTOBER, 1900. No. 8



VIEW OF TRUCK OF THE NEW HARDIE AIR MOTOR CAR BODY REMOVED. THE STEEL STORAGE BOTTLES ARE SHOWN IN THE FOREGROUND. THE LARGE TANK IN THE CENTER IS THE REHEATER. THE ENGINES ARE ON THE OUTSIDE OF THE FRAME DIRECTLY OVER EACH RAIL.

LIDGERWOOD M'F'G CO.,

Boston.
Philadelphia.
Cleveland, O.

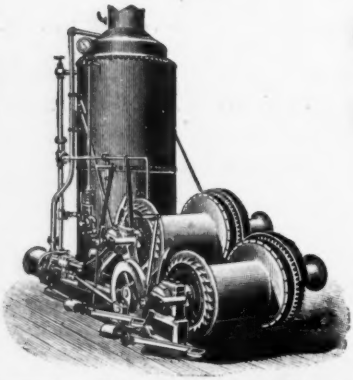
96 Liberty Street,
New York.

Chicago.
Portland, Ore.
New Orleans.

STANDARD

High-Speed Hoisting Engines.

Built on the Duplicate Part System.



Cableways, Hoisting AND Conveying Devices,

For Canal and Trench Excavating, Dam Construction, Wall and Pier Building, Mining, Quarrying, Logging, and General Contract Work.

Fiske Brothers Refining Co.

NON-CARBONIZING OIL

FOR USE IN AIR CYLINDERS OF

AIR COMPRESSORS,

Also All Grades of Lubricants for use on Machinery Propelled by Compressed Air.

OFFICE AND SALESROOM, No. 59 WATER STREET,

CABLE ADDRESS "LUBROLEINE."

SOLE AGENTS FOR GREAT BRITAIN:
JOHN MACDONALD & SON,
GLASGOW, SCOTLAND.

NEW YORK, U. S. A.

FOR

THE WORK OF THE DRILL.

FOR ALL PURPOSES:

COAL, IRON, STONE, WATER, GOLD, SILVER, OIL, COPPER, TIN, ETC.

....SEE....

"Boring and Drilling"

AN ILLUSTRATED TECHNICAL MONTHLY.

Methods of Boring. New Appliances. Sections of Strata, Etc.

RECORDED.

Editorial Office:

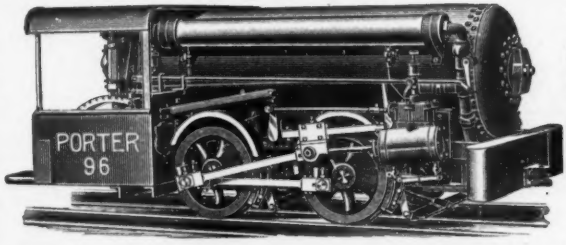
45 Devonshire Chambers, Bishopsgate, London, E. C.

Subscription:

For the year, - - - 10s. with postage.
Single copies, - - - 1s.

SEE SEPTEMBER NUMBER FOR SPECIAL ILLUSTRATED REPORT OF BORING ENGINEERS' CONGRESS AT FRANKFORT. - PRICE 2s.

COMPRESSED AIR MINE HAULAGE.



SAFEST, MOST ECONOMICAL, HANDIEST, MOST ADAPTABLE TO VARYING REQUIREMENTS, AND MOST RELIABLE.

We introduced the first air haulage into anthracite mines, and have installed about 90 per cent. of the air locomotives in use in America. We can refer to some 25 plants in operation, each with one to six locomotives, track gauges 18 to 56½ inches, underground and surface haulage. Our designs are automatic, easily controlled and free from complications.

SPECIAL OFFER: On application of Mine Superintendent or official of operation likely to use locomotives, we will mail free our Ninth Edition "Light Locomotives," 233 pages, describing 600 steam and 60 air locomotives. To accommodate others a copy will be mailed on receipt of 50 cents (in stamps if desired).

Address..... **H. K. PORTER COMPANY, - - 540 Wood St., Pittsburgh, Pa.**

BOSTON. NEW YORK. PITTSBURG. CHICAGO. ST. LOUIS.

National Tube Works Company,

MANUFACTURERS OF

Standard Steam, Gas and Water Pipe.
Locomotive and Stationary Boiler Tubes.
Special Flanged Pipe for Compressed Air.
Pump Columns for Mines.
Special Light Lap-Welded Pipe, fitted with the Converse Patent Lock Joint for Water and Gas Mains.
Cylinders with Dished or Flat Heads for Carbonic Acid and other Gases.

NEW YORK OFFICE, HAVEMEYER BUILDING.

THE PULSOMETER STEAM PUMP

"The Contractor's Friend."

OFTEN IMITATED—NEVER EQUALED.
OVER 20,000 IN USE.

Recent Important Improvements.

The Handiest, Simplest and Most Efficient Steam Pump for General Low Service Mining, Quarrying, Railroad, Irrigating, Drainage, Coal-washing, Tank-filling, Paper Mill, Sewer and Bridge Contractors' Purposes, etc., etc.

Muddy or gritty liquids handled without injury to the Pump.

PULSOMETER STEAM PUMP CO.

Catalogue on Application. **Correspondence Solicited.**

135 GREENWICH STREET, NEW YORK.

The B. F. Goodrich Company.

AKRON RUBBER WORKS. FACTORIES: AKRON, OHIO, U. S. A.

NEW YORK: 66-68 Reade Street. CHICAGO: 141 Lake Street. SAN FRANCISCO: 35 New Montgomery Street.

Rubber Goods

OF FINE QUALITY.

HOSE FOR ALL PURPOSES.

TRADE MARK

AIR HOSE for Rock Drills, Compressors, Mining Machines, Pneumatic Riveters, etc.

ILLUSTRATED CATALOGUE.

STEAM HOSE, Etc.

Belting, Springs of all kinds, Valves, Gaskets, Rings, Packing, etc., etc.

No Floats or Submerged Working Parts.

Section of Chambers.

In sizes from 10 gallons per minute up.

Duplex Displacement Type.

WRITE FOR CIRCULAR

THE MERRILL PNEUMATIC PUMP Operated by

COMPRESSED AIR.

Suited to All Conditions and Places from Which Water is Taken.
Sent on Trial to All Parts of the Country.
Single and Duplex Displacement and Piston Types
Can be Installed by Any Mechanic.

MERRILL PNEUMATIC PUMP CO.,

141 Broadway, New York.

"COMPRESSED AIR" PUBLISHED MONTHLY.

This is the only publication devoted to the useful application of compressed air, and it is the recognized authority on all matters pertaining to this subject.

NOW IN ITS FIFTH YEAR.

RATES OF SUBSCRIPTION.

United States, Canada and Mexico, ... per year, $1.00
All other Countries, ... " 1.50
Single Copies 10

SPECIAL.

Clubs of ten subscribers, ... 5.00

The attention of Engineers, Superintendents, Railroad Master Mechanics, Manufacturers of Compressed Air Appliances, Students, and all others whose association with compressed air require the widest knowledge of the application of air power is called to this **Special Rate.** It enables them to place the magazine in the hands of operators of compressed air apparatus by club subscriptions at an extremly low cost.

LIST OF BOOKS ON COMPRESSED AIR.

Volume No. 4, "Compressed Air," . . . . . cloth, 2.00

March, 1899—February, 1900, inclusive.—The twelve numbers of "Compressed Air," which make up this volume are profusely illustrated with fine half-tone engravings and line cuts of a large number of important applications of compressed air. The articles contained in the above have been widely quoted and treat upon a varied collection of air power subjects.

This volume is valuable for those who contemplate the use of compressed air, and are investigating its advantages.

Compressed Air Production, by W. L. Saunders, . . cloth, 1.00

Compressed Air Production or The Theory and Practice of Air Compression. Just published. By W. L. Saunders. A practical treatise on air compression and compressed air machinery. It contains rules, tables and data of value to engineers.

Compressed Air, by Frank Richards, ... cloth, 1.50

Compressed Air, by Frank Richards. Contains practical information upon air compression and the transmission and application of compressed air.

Liquid Air and the Liquefaction of Gases, by Prof. T. O'Conor Sloane, 350 pages, ... 2.50

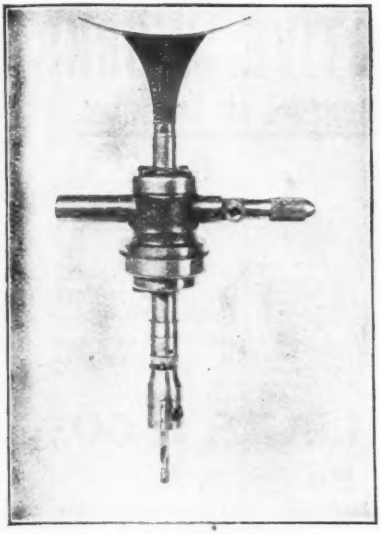
Experiments upon the Transmission of Power by Compressed Air in Paris, by A. B. W. Kennedy, F. R. S., M. Inst. C. E., Emeritus Professor of Engineering in University College, London. The Transmission and Distribution of Power from Central Station by Compressed Air, by William Cawthorne Unwin, B. S. C., F. R. S., M. Inst. C. E., . . . 50c.

The Transmission of Power by Compressed Air, by Robert Zahner, M. E., 50c.

Forwarded postpaid on receipt of price.

"COMPRESSED AIR," 26 Cortlandt St., New York.

EMPIRE AIR TOOLS.



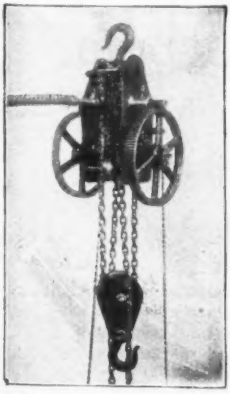
NO. O BREAST DRILL.

All Working Parts Incased.
Gears Run in Oil Chamber.

An important feature which is found in NO OTHER pneumatic drill is an oil chamber enclosing the gears and bearings, allowing them to travel in oil, and avoiding wear, friction and frequent oiling.

No. 00 Drill, Capacity 3/16 in. weight 5¼ lbs.
No. 0 Drill, Capacity 7/16 in. weight 10½ lbs.
No. 0 Extra Drill, Capacity ¾ in. weight 15 lbs.
No. 1 Drill, Capacity 1 in. weight 35 lbs.
No. 1 Extra Drill, Capacity 1½ in. weight 49 lbs.

PNEUMATIC MOTOR HOISTS.



DIFFERENTIAL HOIST.

Take little head-room.
Light, easily handled.
Not dependent on air pressure to sustain load.
Made in following Capacities: Differential, Class "A" Hoists 1,500, 3,000, 5,000 and 10,000 lbs. Friction Brake, Class "B" Hoists, 800, 1,500 and 2,500 lbs.

Our goods are used by the
U. S. GOVERNMENT
in all NAVY YARDS
in the east.

Send for Illustrated Catalog.

FRICTION BRAKE HOIST.

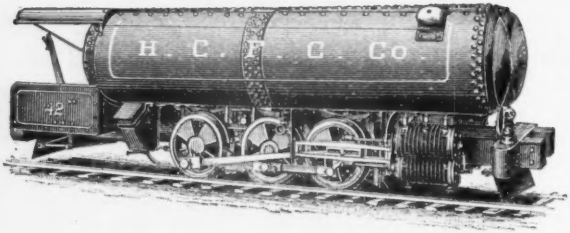
EMPIRE ENGINE & MOTOR CO.,

OFFICE AND WORKS: ORANGEBURGH, N. Y.

Established 1831. Annual Capacity 1,000.

BALDWIN LOCOMOTIVE WORKS,

Single Expansion and Compound Compressed Air Locomotives.



Adapted to a great variety of service. Built to gauges and templets from standard designs.

Similar parts of different engines of same class perfectly interchangeable.

Highest efficiency attained by compounding.

BURNHAM, WILLIAMS & CO.,

PHILADELPHIA, PA., U. S. A.

J. S. THURMAN,

CONSULTING MECHANICAL ENGINEER, DESIGNER COMPRESSED AIR SPECIALTIES,

LINCOLN TRUST BUILDING, ST. LOUIS, MO.

FOUNDRY MOULDING MACHINES

OPERATED BY

COMPRESSED AIR.

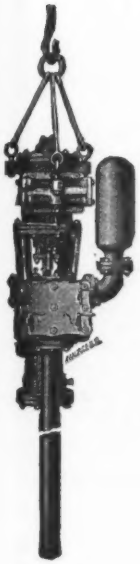
Vibrator principle, avoiding stripping plates and expensive patterns, for both power and hand ramming.

Write us to learn how nearly we have reduced pattern cost to nothing.

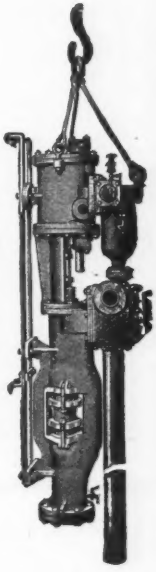
THE TABOR M'F'G CO,

ELIZABETH, N. J.

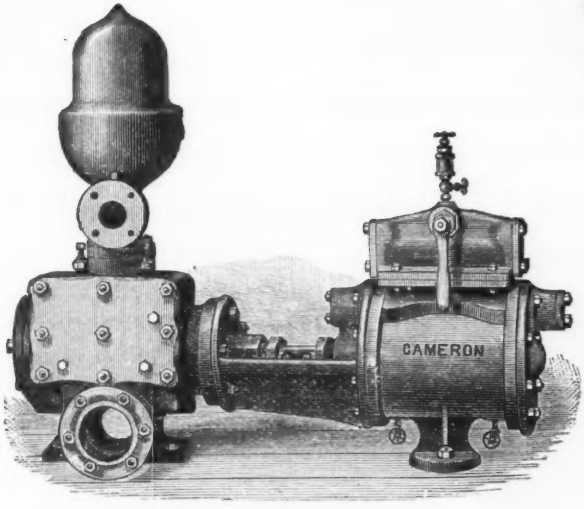
CAMERON STEAM PUMPS.



Simple,
Compact,
Durable,
Efficient.



NO OUTSIDE VALVE GEAR.



ADAPTED TO EVERY POSSIBLE DUTY.

MANUFACTURED BY

THE A. S. CAMERON STEAM PUMP WORKS,

Foot East 23d Street, New York.

Q AND C HAMMER IN STEEL WORKS.

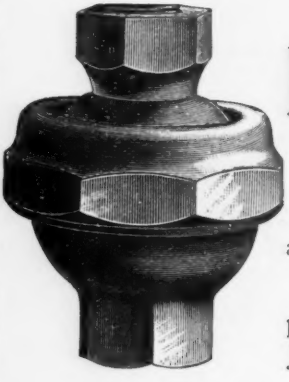
Pneumatic Tools

For
CHIPPING,
CALKING,
BEADING,
RIVETING,
REAMING,
DRILLING,
LIFTING,
And
STONE
CUTTING.

They execute their duties in a thoroughly workman-like manner, doing their work rapidly and with the greatest accuracy.
Send for catalog.

THE Q. & C. CO.
CHICAGO. NEW YORK.

An Important Connecting Link in Compressed Air Service.



THE
Moran Flexible Joint

For high pressure, indispensable.

Tightness, safety, flexibility and durability assured.

Parties making experiments with Compressed Air may have the use of the "Moran Joint" free for a limited time.

MORAN FLEXIBLE STEAM JOINT CO.,
LOUISVILLE, - - - - - KENTUCKY.

Compressed Air.

OR

THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

W. L. SAUNDERS, - - Editor and Proprietor
J. E. QUINTERO, - - - - - - } Associates
M. E. VARIAN, - - - - - - }

Subscription, including postage, United States, Canada and Mexico, $1.00 a year. All other countries, $1.50 a year. Single copies, 10 cents.

Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

All communications should be addressed to COMPRESSED AIR, 26 Cortlandt St., New York.

London Office, 114a Queen Victoria Street.

Those who fail to receive papers promptly will please notify us at once.

Entered as Second-Class Matter at the New York N. Y. Post Office.

VOL. V. OCTOBER 1900. NO. 8.

A serious accident occurred recently in the Tintic District at the Mammoth Mine, Mammoth, Utah. An explosion occurred in the air cylinder of a Duplex Corliss Compressor. The accident was very severe, resulting in the death of the Assistant Engineer, Mr. Charles Meranda, and injury to the Chief Engineer, Mr. William Nesbit. The cause of the explosion has been attributed to the oil in the cylinders. The explosion was terrific; the back head was shattered, while the back flange of the cylinder was torn off at several points, particularly at the top, where a portion of the cylinder was blown away.

At the time of the explosion the Chief Engineer, Mr. William Nesbit, was kneeling in front of the cylinder manipulating the inlet valve pin, while his assistant, Mr. Charles Meranda, was standing close by. Meranda was hurled under a work-bench about 10 ft. distant, badly mangled, while Nesbit struck the wall in an unconscious condition. These two men were alone in the engine room at the time, and we understand that when Nesbit regained consciousness he realized that the compressor was running away and staggered to the throttle, falling down three or four times in attempting to shut off the steam, which he finally did, thus preventing the destruction of the compressor, as the governor was rendered useless by the explosion. Parts of the cylinder head tore out a window and shot 50 or 60 feet beyond the building, and we hear that a piece of Meranda's thigh flesh, the size of your two fists, was found on an ore dump 150 feet away. At the time of the accident they were compressing air to 80 pounds at about 60 R. P. M.

Such explosions fortunately are rare in air compressor service, and they serve to emphasize the importance of using only the best grade of air cylinder oil. Cheap oil has no place in air passages and even with the best oil explosions may occur if too much oil is fed into the cylinder and if sufficient care is not taken to keep the valves and ports clean and free from oil deposit. A form of kerosene engine is made to act on the principle which is illustrated by explosions in the cylinders of air compressors. This oil engine has a chamber which is at first warmed by the heat of a lamp applied externally. After there is sufficient heat to cause the explosion of the kerosene, the

lamp is removed and the temperature of the chamber is sufficient to continue these explosions at each return stroke of the piston, which forces hot compressed air in contact with this oil vapor. Here is an engine acting on the explosive principle similar to that in use in all oil engines, yet there is no spark or other direct means of ignition. In the cylinder of an air compressor as the piston approaches the head it compresses the air to a point which in both pressure and temperature is sufficient to cause an explosion provided there is oil vapor present, the flashing point of which is about the same as the temperature in the cylinder. This flashing point of oil is something of a mystery when the oil is used in compressed air. Ordinarily, the flashing point of oil can be easily determined, but when used in compressed air either the oil is disassociated and separated into component parts or its flashing point is lowered by contact with the heavily oxygened air chamber. Sufficient importance is not given to the water jackets as a means of preventing explosions. In the case of the oil engine referred to the heat of the cast iron effects the explosion and in an air cylinder we have a similar condition in the shape of a hot cast iron cylinder or head. It is not sufficient to water jacket the cylinder only, but if the heads are not jacketed they are likely to become hot and to materially aid in causing explosions. This is especially true where the air is used at high pressures, and where the compressor is run at high speed. It is merely necessary to put one's hand upon the head of an air cylinder in the engine rooms where compressors are used, to note that this piece of metal is very hot.

Products from Liquid Air.

(From Address Delivered before Franklin Institute.)

On the Separation of the Constituent Gases of Liquid Air—Distillation of the Gases—Work of Compression—Cost of Power.

By Prof. Raoul Pictet and Moritz Burger.

It will be our effort in this paper to impress our hearers with the true value of the process by which liquid air has been produced. To make the subject clear, we will give a brief description of the process and the original primitive apparatus.

The present process for liquefying air in quantity and at low cost presents many valuable features for consideration, and is the one along the lines of which past efforts have been principally directed.

It consists, in brief, of compression of the air, cooling after compression by water coolers, and expansion of this compressed and cooled air in a countercurrent, or self-intensifying, apparatus, wherein the cold expanded air flows back over the incoming stream of compressed air and serves to refrigerate or intensify itself down to the critical temperature of liquefaction.

All previous apparatus constructed upon this principle have lacked in one essential feature, namely, insulation against atmospheric heat. The importance of this feature does not seem to have been appreciated, as it has been customary to coil up the tubes forming the apparatus in any convenient or compact form, without regard to protection of the point of critical temperature.

Obviously, when we are dealing with great extremes of temperature, insulation becomes of vital importance, viewed from the point of efficiency or economy. In past practice this lack of insulation has been overcome by the application of increased refrigeration, secured by greater expenditure of power, resulting, in all instances, in excessive cost of production

of the necessary low temperature for the liquefaction of air.

In this primitive condition the art languished, until it was conceived that the point of critical temperature could effectually be protected, or insulated, from atmospheric heat by its isolation within the surrounding coils, and by the outrunning refrigerating streams of cold expanded air, whereby the radiant atmospheric heat would be intercepted and carried outward.

The direct or immediate application commercially of this new process of producing low temperatures lies in its value for the separation of the several gases or components of atmospheric air and making them available commercially.

First, it is necessary to consider the laws of nature, which dominate all gases and vapors. The exactness and value of these laws are comparable with those of astronomy. In our case, we simply apply them to atmospheric air. All vapors, compressed at a certain temperature, rise in pressure to a certain limit, which cannot be exceeded. This limit represents the maximum tension of the vapor. Beyond this limit any change of volume is accompanied by a condensation of the vapors or an evaporation of the gas previously condensed.

The phenomenon of the transformation of the nature of two mixed and compressed gases shows a special character if the liquid obtained out of every one of the gases dissolves itself in the liquid obtained from the other. The main character of this transformation is the following:

It can be said that, in a liquid which represents a solution of two soluble liquids which can be mixed in all proportions, the liquids and the vapors derived from them will never, at any temperature, show the same proportion of weight of their constituents. Always, and without exception, the more volatile constituents of the liquid mixture will create a vapor richer in weight than that of the corresponding constituents, whatever may be their proportions in the liquid which produces the vapors. Thus we obtain out of a liquid mixture composed of 10 per cent. alcohol and 90 per cent. water, at a temperature of 32° F., vapors which contain 64 per cent. of alcohol and 36 per cent. of water in weight. This law is the basis of all processes of distillation and refining of mixed liquids.

It is entirely applicable to liquid oxygen and nitrogen. Both gases become vapors when being cooled to a temperature of 292° F. below zero, but the temperature of liquefaction of one of the gases, the oxygen, under atmospheric pressure lies 25° above the temperature of evaporation of the nitrogen at the same pressure. These two liquids dissolve in any proportion. It may be remembered that the latent heat of evaporation decreases with an increase of the temperature. According to this, liquid air evaporates at a temperature of 317° F. below zero, whereby one pound of liquid air will absorb about 325 B. T. U., while at a temperature of 292° F. below zero, it only absorbs about 305 B. T. U. This reduction allows us to explain, without difficulty, the theory of our process, consisting in the separation of oxygen and nitrogen.

Liquefaction of Air.

The atmospheric air consists mainly of four constituents, only three of which have industrial value. The atmospheric air is composed, at a temperature of 60° F., of nitrogen, 79 to 80 per cent. in volume; oxygen, 21 to 20 per cent. in volume; carbonic acid, from 3 to 50 per 10,000; and watery vapor, about 29 per 1,000 in volume. The problem of the separation consists of the following parts:

First.—Perfect extraction of the watery vapors before further operation. The same would offer many obstacles to the successful operation by its liquefaction and its freezing.

Second.—Extraction of the carbonic acid, which freezes in form of white snow at a low temperature of the gases.

Third.—Liquefaction of the thus purified quantity of air.

Fourth.—Distillation and refining the liquid atmospheric air, collecting the oxygen and the nitrogen in different separate gas holders.

Here it may be mentioned with special emphasis that there exists a fundamental difference between distilling, in our sense of the word, and the general conception of that term. If we distill alcohol, in industry, we introduce it in a liquid form into the apparatus, and after the process

we regain it again in liquid form, in which state it is used for commercial purposes. During the process we introduce heat, thereby converting the liquid to vapors, which are afterward liquefied by condensation.

In our process it is the exact reverse. We take air in a gaseous state and reduce it to a liquid and again evaporate it, in the form of separated constituents, into different gas holders, from where they may be taken for the numerous industrial applications. During the process we cool the gases, instead of heating them. This is, so to say, a reversed distillation, but the functions follow the same laws.

The atmospheric air enters first a filter wherein all dust or foreign matter is removed. This filter purifies the air and delivers it to the compressor, which can be driven by any available source of power. The compressed air then enters a cooler under a pressure of from thirty to 150 pounds per square inch. There it is cooled to about 40° F. below zero. This cooler contains a solution of calcium chloride, which condenses the entire amount of moisture out of the air. After leaving this cooler, the compressed air enters the heat interchanger. This is a very important part of the system. In the interchanger the compressed air is cooled to the temperature of the liquid air by interchanging the temperature of the cold gases of evaporation with the temperature of the incoming stream of new air. The heat interchanger consists of three divisions. It is a tubular apparatus, in which a counter-current of the gases is produced. In the first part, the cold nitrogen, arriving from the separator, flows through a system of parallel tubes, on the outside of which compressed air circulates. In the second part, the nitrogen of the first series is replaced by a mixture of oxygen and nitrogen, which does the cooling of the compressed gases in this part. Finally, in the third part, we have pure or industrial oxygen in the tubes, for interchanging the heat.

The quantity of the separated gases coming from the separator is in weight equal to the quantity of the mixed and compressed gases before entering the separator. By giving the heat interchanger enough cooling area a perfect interchange of heat can be secured, provided the losses through radiation and conduction of heat are a minimum.

Separating the Gases.

The compresed and cooled gases enter the separator at a temperature of about 310° below zero. This apparatus consists of a series of parallel and horizontal trays. Each tray is provided with a flat spiral coil. All these coils are connected between one another, and form, thus, an enormous coil, starting at the top and ending at the bottom of the apparatus.

The liquefier or separator can have any number of these trays—ten, fifteen, twenty, or even more, if a great purity of the separated gases is required. Each tray of the apparatus is connected with the next lower one by means of an overflow. All trays are filled with liquid air. The compressed and cooled air in the tubes lying on the trays, and bathed in liquid air, will liquefy. This liquid air has a milky appearance, as it contains carbonic acid in the solid state. We purify it with filters located at the top of the apparatus. This liquid, as it emerges from the liquefying coil, is purified by filtration, on its way to the trays of the separator. The filtered liquid air then falls by its own weight from the top downward, from tray to tray, to the bottom of the apparatus.

During the passage of the liquid air from the top to the bottom, the entire separation of its constituents, oxygen and nitrogen, is effected. At the same time the necessary supply of liquid air for maintaining the process is continually replaced, and even increased, by an additional amount of work. In effect, the compressed atmospheric air liquefies in the coil under a pressure of from thirty to 150 pounds per square inch, at a perceptibly higher temperature than that of the liquid air which surrounds the coil, and which boils under atmospheric pressure.

As formerly explained, the latent heat of evaporation of the liquid air is smaller under higher pressure than under atmospheric pressure. The higher, therefore, the pressure in the coils, the greater will be the amount of air liquefied, with a correspondingly great amount of liquid air evaporating on the outside, under atmospheric pressure. Under all conditions, the amounts liquefied and the amount evaporated will at least be equal.

The constant precipitation of liquid air from the coil into the upper part of the apparatus maintains a continuous supply upon all of the trays, equaling the already evaporated quantity of liquid air. The process is automatically regulated by the pressure.

The gases evaporated on the first upper tray will be pure nitrogen, because the nitrogen is a great deal more volatile than the oxygen, and the ratio of its weight to that of oxygen is as four is to one. It may be interesting to note that the nitrogen evaporating on the upper trays of the separator has a purity of from 99 to 99½ per cent. In order to collect this gas, it suffices to connect the upper trays with the heat interchanger, and to lead the nitrogen gas from there to the gas holder.

If the amount of the evaporated nitrogen is great enough to diminish the ratio of the gases in the remaining liquid, the proportion of oxygen to nitrogen will be such that the gases evaporated on the next lower trays will begin to show some traces of oxygen.

In the central trays, and especially nearer to the bottom, the evaporated gases will become richer in oxygen. If four-fifths of the original liquid air is evaporated, the remaining oxygen will have a purity of 85 per cent. If nine-tenths of the original liquid air is evaporated, the oxygen evaporating from the last trays will be of 90 per cent. purity. The last twentieth of the original liquid can be considered to be chemically pure oxygen, and may be applied to all purposes to which chemically pure oxygen, hitherto produced in laboratories only, is applicable.

It is obvious that the gases, which, after leaving the separator represent a mixture of oxygen and nitrogen, not applicable industrially, have to be led to the heat interchanger, in order to give up the quantity of energy represented by their low temperature, from whence they may be allowed to escape. However, as soon as the gases evaporating from the last trays are rich enough in oxygen, they will be collected in the gas holder, from where they may be distributed for general use.

It is possible to manufacture this gas in two different qualities, namely, industrial oxygen and pure oxygen. Pure oxygen will always be derived from the final evaporation of the last twentieth of the total liquid. Industrial oxygen can be accumulated after the evaporation of the first two-thirds of the total quantity of the liquid.

The apparatus is constructed so that any particular tray may be connected with any particular gas holder by means of the mere application of simple clapper valves, governing the connection between the trays and gas holders, and between the different trays themselves.

We start with the collection of nitrogen almost perfectly pure; then we will find in the evaporated gas of each successive tray certain quantities of oxygen, which will increase continually toward the bottom. Up to the evaporation of the first half of the original liquid, the total loss of oxygen will not exceed one-fifteenth of its total weight. After the evaporation of the first two-thirds of the original liquid, the evaporation of the oxygen will increase constantly, and with remarkable rapidity.

It is easy to increase the quantity of the chemically pure oxygen obtained in this apparatus, if desired. For this purpose, it suffices to lead the gases evaporated on the trays back to the compressor as soon as they contain over 21 per cent. oxygen. The ensuing liquid is thus much richer in oxygen, as it again enters the separator. To accomplish this, it is only necessary to connect the gasometer, containing industrial oxygen, with the suction inlets of the air compressors. This we call a compound process, which can, of course, be applied for the manufacture of chemically pure nitrogen.

The carbonic acid is collected in duplicate filters, which may be interchanged at intervals during the operation, without interference. Their construction is quite peculiar, and would require too much time to describe in detail. It need only be mentioned that they extract all the carbonic acid out of the air.

If it is desired to increase the quantity of the carbonic acid thus collected, this can be accomplished to an extent amounting to 1 per cent. of all the air treated, by pipe connection from the inlet of the compressors to the chimney of the power plant, or any other chimney under which coal is burned. The ascending gases in chimneys are very rich in carbonic acid, and mix freely with the

outer atmospheric air, and the percentage can, in this manner, be materially increased. This fact is of great importance, as carbonic acid is a product of enormous commercial value.

It is possible to connect any number of trays with one single gasometer during the operation, and control, in this manner, the quality of the collected gases. An arrangement of electric lamps and windows in each tray will permit of regulation by observation. This apparatus for the separation of the gas mixtures can be made of any material, and in different forms, particularly in connection with a system designed to effectually exclude the radiation of heat from the surrounding atmosphere.

Cost of Manufacture of the Gases.

The many experiments which have been made up to the present time permit us to state that air can easily be liquefied in all quantities in an apparatus built according to the foregoing principle, under a pressure of fifteen pounds per square inch. If we consider the results of experiments made as a basis, and take into consideration the friction, the clearance and all imperfection of valves, and all other losses unavoidable in gas compressors, we can accept that we may compress our air to twenty-five pounds, instead of fifteen, which, as before mentioned, would suffice.

Under these conditions, the work necessary for the compression of one cubic foot amounts to exactly 2,038 foot-pounds. Although this work is accepted as excessive, we can calculate that the minimum volume of compressed and liquefied air in a 500-horse power plant will be 8,000 cubic feet per minute. This will result, in an operation of twenty-four hours, in the liquefaction and distillation of air of 11,500,000 cubic feet. The distillation of this quantity of atmospheric air will result, according to previous experiments, in 5,300,000 cubic feet of industrial nitrogen and 3,550,000 cubic feet of industrial oxygen. The quantity of carbonic acid varies, according to the topographical conditions, and to the desire of the manager, between 520 and 5,200 pounds in twenty-four hours.

Cost of Power Production.

Experience in the electric industry indicates that plants of 500 horse power are of satisfactory efficiency. The statistics show that the work of steam plants in the vicinity of seaports and large industrail centers in general costs one-third of a cent. per horse power hour. In this cost are included all expenses of the power plant, such as depreciation, operation, coal, wages, illumination, oils, and small deatils. This cost of one-third of a cent per horse power hour is in many cases high, especially if triple expansion engines are applied. We accept this cost, however, in order to be conservative. The operation of a 500-horse power steam plant would, therefore, cost in twenty-four hours, $24 \times 1 \times \frac{500}{3} = \$40$. To this cost of operation we have to add the special expenses caused by the operation of the separating apparatus and manufacture of carbonic acid. These are:

First.—Wages of the necessary attendants. Two men suffice, if continually present, for the whole operation. One mechanic, day and night, $6. One laborer, $4.

Second.—Maintenance of coolers, small details, and necessary repairs, $6.

Third.—Depreciation. The initial cost of contruction of the complete apparatus for separation of the oxygen and nitrogen will amount to $25,000. Depreciation of 10 per cent. per year will amount daily to $8.

Fourth.—Incidentals, $10; or a total of $74.

Seventy-four dollars will, therefore, cover the cost of production, operation and depreciation of all materials. With this daily expenditure we can produce, then, 3,550,000 cubic feet of industrial oxygen, 5,300,000 cubic feet of industrial nitrogen, and 3,000 pounds of carbonic acid.

Mr. Tripler's liquid air machine is shown in a conspicuous portion of the main building at the Paris Exposition, almost directly opposite the brewery and distillery section. The machine is described as consisting of a Rand three-stage vertical air compressor, driven by a 50-horse

power horizontal side-by-side compound engine. The air is compressed to 2,500 pounds per square inch, and the output of liquid air is to be fifteen gallons per hour. The cans for storing and forwarding the liquid air contain from fifteen to twenty gallons, and consist of four separate open top cylinders, with one inch of felt on the inside of three of them, the inner cylinder being clear to hold the liquid air. There is also an inverted felt covered cylinder put in between the second and third, and each cylinder has a felt lined cover. Such a can has proved sufficient for satisfactorily conveying liquefied air for a 2,000-mile railway journey."

Somewhat further down, in the section of German chemical industries is the Linde liquid air plant, which includes a refrigerating machine to produce the initial cooling effect. The plant is smaller than Tripler's, having a capacity of but eight liters (8.453 quarts) of liquid air per hour. A vertical triple air compressor brings the air to seven atmospheres pressure in the first stage, from seven to fifty in the second, and from fifty to 200 in the third. The compressed air passes from the last pump to a water separator, then through a vertical cylindrical drier containing chloride of calcium, and then to the liquefying apparatus, which consists of two vertical cylinders containing double and triple coils, etc. The exchanger, as the first cylinder is called, has its lower half divided from its upper part, the former containing another double coil, through the inner tube of which the highly compressed air continues its course, surrounded by an expanded ammonia vapor, which cools the air down to—4° F. The refrigerating machine, already mentioned, is used to draw off and liquefy the ammonia vapor and return it to the exchanger, so as to continue the cooling effect. This, it is stated, enables the apparatus to turn out 50 per cent. more liquid air with an expenditure of but two and one-half horse power. Liquid air is produced within twenty-five minutes after starting the machinery.

Compressed Air Machinery

Rock Cutting Apparatus for Mining and Quarrying.

Under this heading come all forms of drills and rock boring apparatus, stone saws and other cutters, and it must be admitted that in this class of machinery American apparatus is superior to the foreign devices shown.

In the first place, with the exception of the various types of rock drills, foreign manufacturers exhibit absolutely no apparatus for quarrying.

Secondly, their rock drills range all the way from those operated by compressed air, through electricity and flexible shafts to hydraulic contrivances, with a preference for auger drills, electrically driven. On the other hand, with the exception of coal augers, American manufacturers adhere to compressed air and steam-driven drills of the reciprocating percussion type, except in the case of diamond drills for taking out rock cores for prospecting and other similar purposes, and extensive and expensive experience has shown the percussion drills to best meet the conditions of mining hard, medium or even soft rock; and, as a result, there are in operation in the United States over 35,000 rock drills operated by steam or compressed air. The American drills are extremely compact, substantial in construction and very simple in design.

Continental practice is not standardized, and the few manufacturers of drilling apparatus have such a small output that each machine is special, there being no attempt at interchangeability of parts.

The best-known American drills, on the other hand, are made in large quantities, and all parts are made with jigs, templates and dies, so that their dimensions are identical. This permits cheap and rapid repairs when parts wear or break.

Again, there are absolutely no delicate working parts, no insulation to be damaged by oil or water, no switches nor

contacts to corrode or burn out, absolutely no danger from sparks igniting gas or explosives, and no danger to men.

American manufacturers have two forms of mountings—the tripod, and what is known as the shaft-bar, or a straight bar on which the drill is mounted. One is used for surface and cut work, the other for shafts and tunnels. Continental makers nearly always insist on a cumbersome carriage with a swinging arm, on the end of which are clamped one or more drills. Sometimes matters are complicated, and a tank, levers, wheels and other devices are added until the machine presents a formidable appearance.

The electric drills are generally of the auger type with twisted or gimlet bits rotated by a geared or belted motor and fed forward by a hand-screw. Usually water is forced down through a hole in the centre of the drill bit and flushes out the hole as the bit advances. These electrical augers may work here, but they never would under the conditions imposed in the United States, for the electrical parts are exposed, and moisture, grit, etc., would soon put an end to their usefulness.

The reciprocating electric drill finds some admirers, and this is shown by there being many manufactured. Extensive experiments with it in the United States have shown its absolute inferiority in efficiency, durability and simplicity, and its continued use, in face of troubles which it develops, can only be credited to a fad and the backing of an enterprising electrical company deserving to sell electrical machinery.

One form of electrical drill makes a very creditable showing in its Exhibition colors, but we would prefer a history of three months' operation before saying much about it. It consists of a motor encased in a watertight box, with a flexible shaft attached to a percussion drill mounted on either tripod or shaft bar. Gearing, a small crank and various springs inside produce the reciprocation and the blow.

Another strong reason for the use of compressed air drills is that the transmission of the air to the drills in pipes is economical. The pipes are easy to install and certain. Further, the introduction of the compressed air into the headings causes a decided current of air, which keeps the workings cool and fresh and incidentally blows out smoke and gases resulting from blasts.

Hydraulic drills mounted on enormously heavy carriages and complicated looking enough to worry a Yankee machinist, it must be admitted, have done good service in special cases, but it can hardly be seriously suggested that they are suited for more than a very few cases, and, indeed, even their friends could not recommend them for quarrying, general mining or rock excavation.

One concern, from the United States, exhibits two special quarrying machines which attract a good deal of attention. The purpose of both of these machines is the same, one of them only being considerably larger. The smaller machine consists of two round bars held parallel in a suitable frame, but mounted on four adjustable legs, so that the frame can be swung through all angles, from vertical to horizontal. On these bars is mounted a carriage, which can be moved back and forth along the bars by a small motor. This carriage forms the support for a powerful reciprocating drill, which may be operated either by steam or compressed air. The drill is equipped with a special cutter, and as it rapidly reciprocates and cuts the rock, it is moved back and forth, thus cutting a narrow slot the length of the machine and to a depth up to 7½ feet.

The other machine consists of a heavy four-wheeled truck supporting a vertical boiler and a powerful special drill, consisting of a cylinder, a heavy piston and rod, and a suitable guide for the crosshead of the piston, which, at the same time, constitutes the clamp for the cutting tools. The machine is also provided with a feeding mechanism which moves it back and forth along the track on which it runs. In this way, a vertical cut 12 feet deep and of indefinite length can be made.

If the types of apparatus signify anything, it may be stated quite conclusively that American methods and apparatus for general quarrying and mining purposes are in advance of continental practice. No doubt this can be attributed to cheapness of labor, conservatism, and, perhaps, a certain amount of self-satisfied feeling among continental mining concerns.

J. J. S. in London Engineering Times.

Air Compressors.

Compressed air, to the average mind, conveys a rather vague meaning, which ranges from the old-fashioned pop-gun to liquefied air. That is produced by some form of pump is generally understood, but what the pump is, how it works and the principles governing its best action are unthought of points by the layman. The expert, on the other hand, knows the principles involved, and is constantly on the lookout for improvements in details of apparatus. From this standpoint, it is interesting to examine the air compressors exhibited at the Paris Exposition.

In the first place, the number of such compressors is limited, there being, so far as is known to the writer, three compressors in operation on the Champ-de-Mars and three at Vincennes, and several other stationary ones. Of these former, five are American machines. Of course, Paris is an extensive user of compressed air, and its pneumatic street railways, clock and postal systems are unique; but this apparatus does not form part of the Exposition, and it is, therefore, outside of the purpose of this paper to discuss this.

Generally speaking, compressors of all manufactures are horizontal, and the wisdom of having air cylinders behind and in direct line with the steam cylinders seems to have made this form standard practice, as it has certainly been adopted by the important manufacturers on both sides of the water.

The engine may be termed girder framed, either cross, duplex or compound, depending upon initial steam pressure, which, in the United States, averages close upon 100, while on the Continent it is nearer 75 pounds. Slow speed engines, with a fairly long stroke, are used, the American builders favoring a much longer stroke than the Continental, at least, in the larger sizes.

Cranks are set at 90 degrees, thus balancing better and distributing the load over the entire stroke. With one or two exceptions heavy flywheels are universal, the necessity of carrying the cranks past dead points being very important and fully understood. One maker, however, has an extremely light wheel, the wisdom of which may be seriously questioned.

Regarding steam valve mechanism, Continental manufacturers lean towards slide valves of the Meyer's type, even in the larger sizes of engines, although poppet and modified Corliss valves are also used in the larger sizes. Manufacturers in the United States prefer the Corliss valve, excepting smaller sizes or those forms intended for places such as coal mines, where steam economy is a minor item.

In a general way, the engines may be termed average, conforming to usual Continental engine practice, certainly no better, and, perhaps, not so good as American practice for the same class of work.

Coming to the air-compressing portion, such as the cylinder valves, etc., some interesting departures, or, perhaps, we may say, antiquities, are noticeable. The larger sizes follow the usual practice of placing the air cylinder on a separate portion of the foundation and holding it at its proper distance by means of bolts or distance pieces. In the case of the smaller sizes, some manufacturers mount all working parts on one base, but the self-contained type, familiar in the United States, is not generally to be observed, and, when used, it is a clumsy, awkward appearing affair.

It is when the valves and cooling methods are examined that the chief difference is found. With few exceptions, Continental practice leans towards slide valves, the "Weiss" system. This is nothing more or less than a balanced plate slide valve. No particular effort seems to be made to reduce clearance in this type.

In low pressure work for blowers, poppet valves in the heads are, however, used to some extent. But it is safe to say that on the Continent air compressors for pressures of from 3 to 7 kilos, or

even higher, slide valves are the rule. In the United States, with few exceptions, slide valves for air cylinders have been abandoned entirely by progressive manufacturers.

It is interesting to note that Continental steam engine practice employs balanced poppet valves, and for their compressors slide valves. In the States, on the contrary, engines are equipped with slide and Corliss valves, and compressors with poppet valves.

Attention must be called to one type of compressor which is somewhat common. This form resembles a duplex or cross compound engine, the engine portion forming one side and the compressor the other. This type requires heavy cranks, shaft and flywheel, and cannot be as satisfactory as other types, although it is a common type.

Methods of cooling differ. The old injection system of spraying water into the cylinder with the inlet air still finds favor and is employed to some extent. Cylinders are in other cases jacketed fairly well, but the valve of the slide valve types cannot of necessity be cooled, and, in addition, the entering air is in very close contact with the outgoing compressed and hot air.

Compound compression is rather rare, at least for average pressures, and consequently no attempt is made at intercooling, which, in the United States, is considered an important feature. After cooling, or a consistent effort to remove moisture after compression, is not considered necessary, largely because low pressures are used and transmission to any considerable distance is seldom attempted.

Contrasted from the standpoint of general appearance, that is, neatness of design, it must be admitted that the American machines have a solid, compact and business-like look which is most pleasing to the practical eye. When it comes to "finish," using the term to mean paint, varnish and nickel plating, it must be admitted that generally the Continental apparatus makes the best showing. Inspection, however, shows splendid work and materials on the essential parts of the American machines, with an accuracy which leaves little to be desired.

J. J. S. in London Engineering Times.

Tunneling by Compressed Air.

Compressed air is to be employed as the power to dig New York's great rapid transit tunnel. Within two weeks a compressor plant costing $60,000 will be in full blast at the north end of Union Square. This particular plant will operate the hoisters, drills, &c., used by Holbrook, Cabot & Daly, of Boston, who have the contract for section 3 of the tunnel, which begins at the middle of Great Jones street, in Lafayette Place, and runs along Lafayette Place to Astor Place, thence to Fourth avenue, to Park avenue, to Thirty-fourth street.

Workmen are engaged in laying five-inch steel pipe six inches below the surface and along the curb on the west side of Fourth avenue. This pipe line will be connected with the compressed air plant, and can be tapped for power at any point as readily as gas or water mains could be tapped.

Henry B. Seaman, engineer for Holbrook, Cabot & Daly, talked of the work, which may now be said to be really under way.

"At first," he said, "we considered the advisability of using electrical machines for power, but they proved impracticable. They are largely experimental as yet. What we sought was something that would prove applicable over the whole of the work, at the same time being as economical and as little of a nuisance as possible.

"The question arose as to whether steam or compressed air would be employed and the latter was selected. With steam it would be necessary to have separate boilers for each hoister and a set of drills, and this would necessitate having two or three boilers on each block. Soft coal would have to be used, too.

"So we decided to put in a $60,000 compressor plant in an enclosure at the north end of the park. Pipes from the plant will have three or four inlets to each block, and we can have power at any point. Escaping air will not be objectionable like steam, and there will be no offensive odors. There will be no danger of frightening horses.

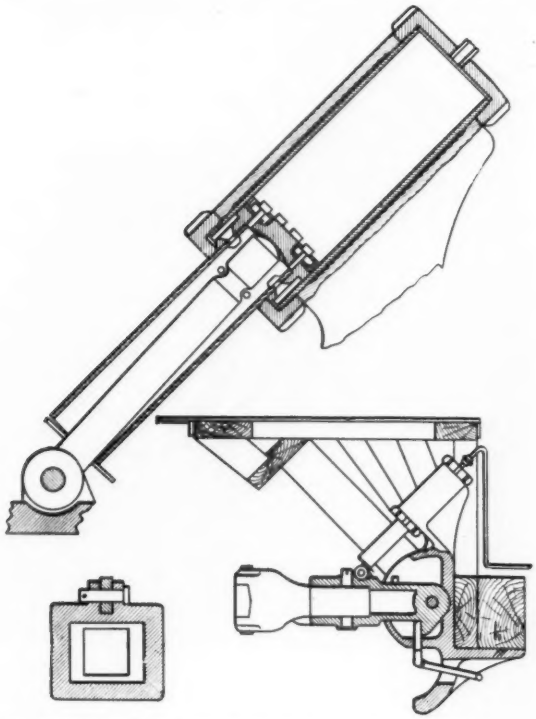
"There will be five boilers in the plant. The first of these will arrive next Tuesday. The pressure will be from eighty to one hundred pounds to the square inch."

No especial machinery to be used on the work has yet been made, Mr. Seaman said, with the exception of a derrick designed to impede traffic as little as possible. As the work progresses, however, special devices will probably have to be employed, as in all such big undertakings.

"Just what devices we will have to use," said Mr. Seaman, "it is impossible to say at the present time. We will have to wait and see the condition of affairs under ground. We expect to strike considerable rock between Fourteenth and Twenty-second streets."

Pneumatic Drop Pilot Coupler, S. A. & A. P. Ry.

The universal adoption of the M. C. B. coupler has rendered it almost imperative to equip the pilot end of the locomotive with a coupler head of this type. With a pilot of useful length, however, the coupler head is necessarily thrown so far out in front that the function of the pilot is very nearly destroyed. It has been endeavored to overcome this objection by providing an arrangement whereby the coupler head and its shank



PNEUMATIC DROP COUPLER, S. A. & A. P. RY.—FIG. I.

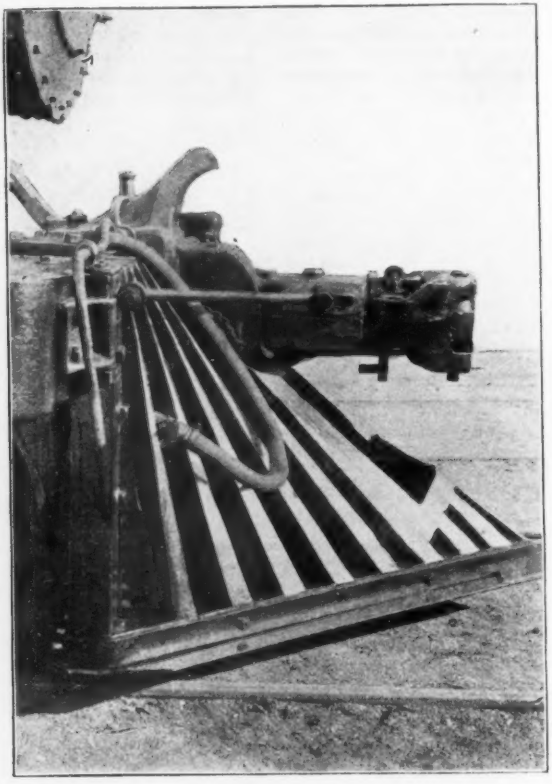
Excavations will be made for a short distance at a time, and photographs will be taken before the street has been torn up and after the section is complete, as the contractors desire to show that they will leave the pavement in as good condition as it was before they touched it.

can be dropped down when not in service, to a position in which it will not interfere with the utility of the pilot as shield for throwing obstructions off the track.

There are in use on various roads many different forms of arrangement by

which this is accomplished. The use of air as a means of raising and lowering the heavy coupler seems to be the favorite line along which the designers work. We have from time to time illustrated in these columns various types of pneumatic drop rigging for pilot couple heads, but in the illustrations in connection with this article there are given views of what would appear to be about as simple, compact and serviceable a design as is likely to be produced. A number of locomotives on the San Antonio & Aransas Pass Railway have been equipped with the arrangement shown, and some months of service has proved the mechanism so satisfactory as to justify the extension of its application into general use.

The design was worked out by Mr. George W. Butcher, superintendent of machinery for this line, and it is through his courtesy that we were enabled to obtain the material from which the illustrations have been made. As will be seen in Fig. 1 the bumper or draw casting is shaped to receive a hinged socket into which the coupler head is pinned. A projection of the draw casting provides below a recess into which slips the piece of pipe which forms the pneumatic raising cylinder. In the cylinder thus formed a push piston throws out when needed the arm which raises the coupler



PNEUMATIC DROP COUPLER, S. A. & A. P. RY.—FIG. 2.

head socket. It will be noted that very little machining of the parts is required as there is no necessity for accurate fitting. When the coupler head is thrown up a pin drops over a projection at the hinged end of the coupler socket which retains the coupler in its raised position until withdrawn by means of the unlocking arm. The view in the latter figure is unfortunate in that the lateral slide braces were found to be unnecessary and have lately been discarded. Mr. Butcher holds the rights to the design, but states that he will willingly reply to any correspondence from those who might wish to use the arrangement.

Railway and Eng. Review.

Compressed Air Haulage Plant at No. 6 Colliery of the Susquehanna Coal Company at Glen Lyon, Pennsylvania.

Paper read at August meeting American Institute Mining Engineers.

(The No. 6 Shaft plant was put in operation in September, 1895, and the No. 6 Slope Motor in May, 1896.)

The plant consists of one Norwalk Three-Stage Compressor, 12½", 9½" and 5" diameters air and 20" diameter steam cylinder, all 24" stroke, capacity at 100 revolutions 296 cubic feet free air per minute, compressed to 600 lbs. per square inch. Main pipe 5" diameter, 4390 feet long, with five charging stations in No. 6 Shaft, and a branch of 3" pipe 3100 feet long, with three charging stations in No. 6 Slope. Each of these two lines charges a Porter Compressed Air Motor with 7" x 14" cylinders, four 24" drivers, weight about eight tons, with a tank capacity of 130 cubic feet of air at 550 lbs. pressure in the main tank, reduced to 160 lbs. in the 8" auxiliary tank, 4.2 cubic feet capacity supplying the cylinders. The No. 6 Shaft run averages 4000 feet each way on grades of ½% to 2¾%, and averaging close to 1% in favor of the loaded cars. The No. 6 Slope run averages 2100 feet, with nearly the same grades. The mine cars weigh 2800 lbs. empty and about 9800 lbs. loaded, and are hauled in trips of 12 to 20, averaging about 15 cars. The Shaft motor now hauls about 355 and Slope motor 320 cars per day of ten hours. Replacing in the No. 6 Shaft 17, and in the No. 6 Slope 15, total 32 mules, against 27 mules replaced in 1896.

The average daily car and ton mileage of each motor was as follows:

	Cars Hauled.				Tons Hauled One Mile.		
	1896	1897	1898		1896	1897	1898
No. 6 Shaft Motor.....	355	347.4	356	Empty, in....	336	330	338
				Loaded, out..	1180	1155	1183
				Total	1516	1485	1521
				Net load...	844	825	845
No. 6 Slope Motor.....	288	288.7	319.2	Empty, in....	143	144	160
				Loaded, out..	501	504	560
				Total.....	644	648	720
				Net load...	358	360	400
Total both motors, gross (including empties returned).....					2160	2133	2241
Net load.....					1202	1185	1245

The use of steam and air in compressor and motor operation as found by test was as follows:

STEAM.

Indicated H. P., compressor @ 130 revolutions.....150 H. P.
Steam consumption per H. P. per hour, from cards.....34 lbs.
Steam consumption per hour, from cards.....5100 lbs.
Steam consumption per hour, including condensation in line.....5200 lbs.
Boiler H. P. required.....174 B. H. P.
Evaporation per pound of coal (cylinder boilers).....5 lbs.
Coal required per hour.....1040 lbs.
Coal required per day, 10 hours.....10,400 lbs., 4.65 tons
Cost of fuel and firing per day, 10 hours, 4.65 tons @ 50c.....$2.32

AIR.

COMPRESSOR CAPACITY.

Free air compressed per revolution of compressor, 2.96 cu. ft. (from calculation by Norwalk Iron Works Co., no allowance for leakage).
The compressor works 12 hours per day to 10 hours for the motors.
Free air per min. at rated speed 100 revs.....296 cu. ft.
Free air per min. at actual speed 131 revs.....387.8/10 cu. ft.
Free air per day, 12 hours at rated speed, 100 revs.....213,120 cu. ft.
Free air per day, 12 hours at actual speed, 131 revs.....279,216 cu. ft.

CAPACITY OF AIR MAINS USED AS RESERVOIR,--

5 inch line 4380 feet.....	608 cu. ft.
3 inch line 3100 feet.....	159 cu. ft.
Both lines.....	767 cu. ft.

At 600 pounds pressure these lines hold 32,505 cu. ft. free air; capacity of main and auxiliary tanks 134.6 cu. ft. at 508 lbs. pressure (at which pressure they will equalize with main starting to charge at 600 lbs.), 4845 cu. ft. free air.

LEAKAGE OF AIR MAINS.

Loss of pressure standing 12 hours, from 550 to 350 lbs.
Cu. ft. free air lost 11,688 cu. ft. in 12 hours,—974 cu. ft. per hour.
Percentage of leakage to total air compressed, 4 18/100%.

AIR USED BY MOTORS.

(From test of March 29, 1900.)

	Shaft Motor. No. 2 Plane.	Shaft Motor. No. 3 Plane.	Slope Motor.
Number trips empty.....	3	10	16
Number trips loaded.....	3	10	15
Average cars per trip, empty.....	15⅓	12 7/10	11 4/10
Average cars per trip, loaded.....	13	13	11 3/10
Average cu. ft. free air per trip, empty.....	1724	5686	1230
Average cu. ft. free air per trip, loaded.....	1631	1898	599
Average cu. ft. for round trip.....	3355	7584	1829

SUMMARY OF DAY'S WORK, 1898.

Shaft No. 6, 356 cars per day,
6 trips, 15 cars No. 2 Plane..... 20,130 cu. ft.
20 trips, 13 2/10 cars No. 3 Plane..... 151,830 cu. ft.

Slope No. 6, 320 cars per day, 28 trips, 11 4/10 cars, average	51,212 cu. ft.
	223,022 cu. ft.
Free air apparently compressed as above	279,216 cu. ft.
Per cent. accounted for	83 4/10%

The difference 16 6/10% is due to leakage and slip in compressor, leakage of air lines and to changes in temperature.

AIR USED PER TON MILE.

	Gross.	Net.
Average free air used per ton mile, No. 6 Shaft Motor	113 cu. ft.	203 cu. ft.
Average free air used per ton mile, No. 6 Slope Motor	71 cu. ft.	128 cu. ft.
Average free air used per ton mile, both motors	100 cu. ft.	180 cu. ft.

The greater quantity of air used by the Shaft than by the Slope Motor is due to the heavier curves and the switching required, especially at No. 2 Plane, where a portion of the trip is frequently left.

COST OF PLANT, NOT INCLUDING STEAM BOILERS.

Compressor	$2,880.00
Extras for compressor repairs	75.75
Shaft Motor	2,743.63
Slope Motor	2,918.20
Extras for motor repairs	207.93
Air connections, 5" line (6000 feet)	2,914.32
Air connections, 3" line (4000 feet)	1,240.46
Steam connections, compressor	278.27
Material for compressor foundations and house, and air washing box	295.27
Labor, compressor house and foundations, and 5" line, and installing Shaft Motor	1,183.01
Labor, 3" line and installing Slope Motor	46.95
Foster equalizing valves	372.21
Total cost of plant	$15,156.00

COST OF OPERATION OF PLANT.

Operating Expenses.	1897 179 Days Worked. Per Day.	1897 179 Days Worked. Per Yr.	1898 160 Days Worked. Per Day.	1898 160 Days Worked. Per Yr.
2 motor engineers @$2.10	$4.20	$751.80	$4.20	$672.00
2 brakemen @ 1.60	3.20	572.80	3.20	512.00
½ one engineer compressor @ 2.32	1.16	207.64	1.16	185.60
Oil for compressor	.67	119.49	.47	75.94
Oil for motors	.25	45.08	.25	40.94
Repairs for compressors (material)	.10	18 76	.48	76.08
Repairs for compressors (labor)	.06	10.38	.09	15.22
Repairs for motor (material)	.16	28.78	.51	81.08
Repairs for motor (labor)	.18	32.77	.23	36.87
Steam for compressor, 150 H. P., fuel and firing	2.32	415.28	2.32	371.20
Total operating expenses	$12.30	$2,202.78	$12.91	$2,066.93

FIXED CHARGES.

Interest, repairs and depreciation, 174 H. P. boilers..	$1.46	$261.00	$1.63	$261.00
Interest and depreciation of plant, 10% on $15,156.00.	8.47	1,515.60	9.47	1,515.60
Total fixed charges.....	$9.93	$1,776.60	$11.10	$1,776.60
Total cost 2 motors, ½ for each.....	22.23	3,979.38	24.01	3,843.53
Estimated cost per day, 300 days' work.....	18.22	5,466.60	18.83	5,649.60

THE COST PER TON MILE.

	1897. (179 DAYS).			1898. (160 DAYS).		
	Daily Mileage.	Daily Cost.	Per Ton Mile.	Daily Mileage.	Daily Cost.	Per Ton Mile.
No. 6 Shaft Motor, gross ton mileage.	1485	11.12	75/100c	1527	12.00	79/100c
No. 6 Shaft Motor, net ton mileage ...	825	11.12	1.35/100c	845	12.00	1.42/100c
No. 6 Slope Motor, gross ton mileage..	648	11.12	1.72/100c	720	12.00	1.67/100c
No. 6 Slope Motor, net ton mileage....	360	11.12	3.09/100c	400	12.00	3.00/100c
Both motors, total gross ton mileage..	2133	22.30	1.05/100c	2241	24.01	1.07/100c
Both motors, total net ton mileage	1185	22.30	1.89/100c	1245	24.01	1.93/100c

THE COST OF MULES DISPLACED BY THIS PLANT.

No. 6 Shaft, 17 @ $126.64.....	$2,152.88
No. 6 Slope, 15 @ 126.64.....	1,899.60
	$4,052.48

OPERATING EXPENSE BY MULES.

NO. 6 SHAFT.

	1897. (179 DAYS').		1898. (160 DAYS).	
	Per Day.	Per Year.	Per Day.	Per Year.
Depreciation and interest on 17 mules @ 25%..	$3.01	$538.22	$3.36	$538.22
Feeding, attendance, harness and repairs @ $141.40	13.43	2,403.80	15.02	2,403.80
Six drivers	9.40	1,682.60	9.40	1,504.00
Six couplers and spragmen	8.10	1,449.90	8.10	1,296.00
Total cost by mules.....	$33.94	$6,074.52	$35.88	$5,742.02
Cost by motor	11.12	1,989.69	12.00	1,921.77
Saving by compressed air.....	$22.82	$4,084.83	$23.88	$3,820.25

NO. 6 SLOPE.

Depreciation and interest on 15 mules @ 25%..	$2.65	$474.90	$2.97	$474.90
Feeding, attendance, harness and repairs @ $141.40.....	11.85	2,121.06	13.26	2,121.06
Five drivers.....	8.00	1,432.00	8.00	1,280.00
Five couplers and spragmen.....	6.85	1,226.15	6.85	1,096.00
Total cost by mules	$29.35	$5,254.11	$31.08	$4,971.96
Cost by motor.....	11.12	1,989.69	12.00	1,921.77
Saving by compressed air.....	$18.23	$3,264.42	$19.08	$3,050.19

BOTH No. 6 SHAFT AND No. 6 SLOPE.

Total cost by mules	$63.29	$11,328.63	$66.96	$10,713.98
Total cost by motors	22.23	3,979.38	24.01	3,843.53
Saving by compressed air	$41.06	$7,348.25	$42.95	$6,870.45

Total saving in two years $14,218.70
Total cost of plant 15,156.00

At the average rate of saving for 1897 and 1898 the entire cost of plant would be saved in 361 working days.

COST PER TON MILE BY MULES.

	1897 TONNAGE.			1898 TONNAGE.		
	Ton Mileage.	Cost.	Per Ton Mile.	Ton Mileage.	Cost.	Per Ton Mile.
No. 6 SHAFT.						
Gross ton mileage	1485	$33.94	2.29/100c	1527	$35.88	2.35/100c
Net ton mileage	825	33.94	4.11/100c	845	35.88	4.25/100c
No. 6 SLOPE.						
Gross ton mileage	648	29.35	4.53/100c	720	31.08	4.32/100c
Net ton mileage	360	29.35	8.15/100c	400	31.08	7.77/100c
TOTAL.						
Gross ton mileage	2133	63.29	2.98/100c	2241	60.96	2.98/100c
Net ton mileage	1185	63.29	5.34/100c	1245	60.96	5.38/100c
COST BY MOTORS.						
Total gross ton mileage	2133	22.30	1.05	2241	24.01	1.07/100c
Total net ton mileage	1185	22.30	1.89	1245	24.01	1.93/100c
SAVING BY COMPRESSED AIR.						
Gross ton mileage	....	40.99	193/100c	....	36.95	1.91/100c
Net ton mileage	....	40.99	345/100c	....	36.95	3.45/100c

The capacity of the Shaft Motor is equal to fully double its present work, while the Slope Motor is working at but about one-third of its capacity, while the compressor is doing all that it is capable of, and a second one was ordered April 7th, 1900. To operate the plant to the full capacity of both compressors, which, under the present conditions, would be about 4500 ton miles gross or 2500 net per day for 300 days per year would bring the cost of operation, including fixed charges, to about $24.60 per day or 547/1000 cents per ton mile gross and 984/1000 cents per ton mile net load. While if all the work could be done by one motor under the No. 6 Shaft conditions up to the capacity of the compressor for 300 days per year, using only one crew, the cost of plant would approximate $11,000 00, and the operating expense, including fixed charges, $10.86 per day for 2400 gross ton miles, equal to 45/100 cents per gross ton mile and 81/100 cents per net ton mile.

A further reduction of cost could be made by reheating the air at the motor by passing it through water at the temperature of steam at 90 pounds pressure, by which method tests have shown a gain of about 50% in air economy. It is probable that by this means one motor could be run to its full capacity about 3000 gross ton miles per day with one compressor at a total cost of $10.80 per day, or 36/100 cents per gross ton mile, for 300 days' work per year; the saving of 9/100 cents per gross ton mile, or about 20% over the last mentioned condition, being due only to the greater air economy, the fixed charges and labor cost remaining practically the same.

J. H. BOWDEN, C. E.

Electricity in Mining.

By Henry Louis, M. A., A. R. S. M., F. G. S., &c.
Professor Mining, Durham College of Science, Newcastle-on-Tyne.

It has already been pointed out that electric percussion drills have not so far been at all successful. Two principles have been made use of in these drills, some deriving their reciprocating action from the sucking power of solenoids, others striking a blow under the action of a spring, which is compressed by a cam, and, when released, allowed to shoot the drill forward, or else, actuating the drill by some form of crank; that is to say, the latter class convert the rotary motion of the motor into a reciprocating movement. Solenoid drills, of which the van Depoele and the Mavin are examples, have not proved satisfactory, the main difficulties being the treating of the coils of the solenoid and want of power in the blow. Mavin drills have been used in one or two places, but no accurate data as to the results obtained are available. The solenoid drill made by the Union Electricitates Gesellschaft strikes 350 to 500 blows per minute, requires 4 h. p., and is said to drill about two inches per minute. The Bladray drill is one of the neatest forms of the second type, spoken of sometimes as electrical mechanical drills. In this drill the drill stem is encircled by a cylindrical cam which forms the continuation of the hollow armature of a small motor. The cam works against a scroll-shaped cylindrical tappet, which is a portion of the drill stem, and is presssed forward by a powerful spring. As the cam revolves the tappet is pressed back against the spring till it clears itself, when the spring shoots it forward, striking the blow. This drill strikes 700 3-inch blows per minute, and has been used in South Africa; but nothing is yet known of the results obtained by it. Messrs. Siemens and Halske make a percussion drill very like the Ingersoll hand drill, fitted with a heavy flywheel, and worked by means of a separate motor, the cam of the drill and the motor being connected by a flexible shaft. This machine strikes 450 blows per minute, and is said to be capable of boring a 1½-inch hole into hard granite at the rate of 4 inches per minute with the consumption of 1 h. p. It need hardly be said that if these results can really be obtained in practical work it would be a most valuable machine, and far more efficient than any compressed air drill. It has hardly yet passed beyond the experimental stage, and is, moreover, a cumbersome and clumsy machine. A more modern type is the Bornet drill, which has been used in the south of France. This drill is actuated by a separate motor, the connection between the two being by means of a flexible shaft on a double Hooke joint; this works a crank shaft, the crank moving a solid piston backwards and forwards. The piston is enclosed in a cylinder, to the front cover of which the drill is attached; the action is thus precisely similar to that of the Scholl pneumatic stamp, the air compressed alternately in either end of the cylinder acting as a spring and giving the machine the required elasticity. As already said, electric percussion drilling is, as yet, very far from being a success.

Rotating electric drills have given excellent results wherever they are applicable, which is, of course, only in the softer rocks, such as ironstone, salt and coal. One of the best of these drills is that designed by Mr. A. A. Steavenson and made by Messrs. Easton, Anderson & Goolden (Limited), for use in the ironstone mines of the Cleveland district. It consists of a carriage supporting a standard capable of being turned in any direction, which carries an arm, on one end of which is supported a small direct current motor, whilst the other end carries a twist drill driven by means of bent gearing, the connection between the drill and its driving shaft being made by a Hooke joint, so as to allow the drill perfect freedom of motion. Such a drill works at 220 volts, and requires 20 ampères, or (say) 6 h. p. at the drill. It makes 100 revolutions per minute, and drills in ironstone at an average rate of 3 feet to 4 feet per minute; in a working shift of ten hours each drill will put in 100 holes, averaging 4 feet to 5 feet deep, in about eight different working places. Messrs. Siemens & Halske make a twist drill, worked from a separate motor by means of a flexible shaft. It is used in the salt mines of New Stassfurt, where it has given good results; its rate of advance is controlled by differential gear. The motor is of 1 to 1.5 h. p.; the drill makes

200 revolutions per minute, and drills about 1 foot in depth in from 1 to 2 minutes. The General Electric Company makes an electric twist drill connected directly with the motor. It absorbs 2 h p., makes 300 revolutions per minute, and drills 1 foot in depth in 30 to 40 seconds. These machines are quite effective for boring in coal, for which purpose the Jeffrey drill is particularly well adapted on account of its lightness, portability and compactness. It works at 220, 350 or 500 volts, and will drill to a depth of 6 feet in about a minute.

Electric motors present quite special advanatges for working diamond drills, and have been largely used for that purpose, both at surface and for explorations underground. A drill working a 2-inch hole and bringing up a 1⅜-inch core, capable of drilling easily to a depth of 600 feet, can be driven by a 2¾-h. p. motor, the whole arrangement being compact in the extreme and suitable for prospecting underground or in awkward situations where steam could hardly be used. The only rival that electricity has to compete with under such conditions is the oil engine, and it is obvious enough that the latter has many serious drawbacks, especially underground. The rapid rotation of the diamond drill renders it particularly suitable for electric drivage. Were it not for the prohibitive price of the diamonds required, it is probable that electrically driven diamond drills would have been used extensively before this for drilling shot holes, and, as already said, it needs only the discovery of a suitable substitute to place this mode of boring high amongst the most important of mining appliances.

Electric locomotives have been used a good deal in America, and also on the Continent of Europe. Some are worked by means of secondary batteries, but the majority take their power off wires running along the roof or sides of the drift. Except in fiery mines, no more convenient or economical method of haulage can be devised where large quantities of mineral have to be transported considerable distances, whether underground or on the surface. Electric locomotives have been built by the Jeffrey Company, the General Electric Company, Messrs. Siemens & Halske, and others. These locomotives usually run at from 200 to 400 yards per minute, and can ascend grades of 5 per cent. When this inclination is exceeded, rope haulage is generally preferable. In addition to the general advantages of electricity over steam underground, the electric locomotive has that of great compactness combined with ample power, electric mine locomotives capable of developing a drawbar pull of 10,000 lbs. having been built and worked successfully. Polyphase motors have been used, but most locomotives are worked with continuous current. The useful effect of an electric locomotive is usually 70 per cent. of the electric power in the conductors, expressed in terms of drawbar pull. Mine locomotives are usually of 10 to 15 h. p., the weight of the former being about 2½ tons; but in special cases much larger and heavier locomotives are employed. As has already been pointed out, underground traction by means of electric locomotives presents practically the same problems as does ordinary traction at the surface, and is, therefore, rather a matter for the electrician than for the mining engineer.

Notes.

The Philadelphia & Reading R. R. have closed a contract for the installation of a Pneumatic Interlocking plant to operate the switch and signals of the rearranged track system at Wayne Junction. The plant is to be operated by compressed air.

A complete pneumatic railway is being constructed by the H. K. Porter Locomotive Works. The line will be 12 miles long, and will be laid with light rails. The locomotives will be operated by air and the line is constructed for the purpose of conveying powder to the government magazines near New York on Iona Island. The new pneumatic locomotive will weigh about 40,000 pounds, and will have 16-inch cylinders. There is another similar line located in California which was constructed for a powder company in that State two years ago.—Railway and Engineering Review.

It is said that the Incandescent Coal Oil Lamp is the latest invention brought to the attention of Ottawa capitalists.

The incandescence is created by blowing a thin stream of coal oil in a spray over a film, which is shaped like the Auer light burner, and the result is then claimed to be the light of, say, 20 times the brilliancy of an ordinary 16-candle-power electric light. The cost is 1-10 of a cent per hour. To an ordinary students' coal oil lamp the inventor, Mr. Emerson, has attached a small box, into which air is forced by means of a pump, and it is there compressed. The air is connected with the oil chamber, and the air, pressing upon the oil, forces it through a tiny hole in a pipe leading to the burner. This pipe is curved like the letter S, and when the oil escapes from the pipe it is spray, and is cast over the film, where it burns with great brilliancy. One of these lamps has been set up by the inventor, and is giving wonderful light. A heating arrangement on the same basis is also said to be giving great results.

Our attention has been attracted to a case where a receiver took fire on the inside repeatedly. On examination it was found that the drain had only let the water off, leaving a sediment of oil. This was immediately cleansed and the drain enlarged, but it did not, however, remedy the cause of complaint, although it improved matters somewhat.

On asking for advice, they were told that there was something abnormal about the condition of the plant, and were advised to resort to means of cleaning out the compressor and receiver at least once a month, investigating the air compressor to see if the valves were not clogged up, thus causing an excessive temperature in the air cylinder. They were then recommended not to use oil for one day, but instead to use soap suds in the air cylinder, admitting them by the regular lubricator. This would clean out the cylinder. Next a good grade of air cylinder oil should be secured, and only a proper amount of it used—say one drop per five minutes.

These instructions remedied the trouble almost immediately, and we quote the fact thinking the matter might prove of some interest to our readers in general.

A very noticeable point about a railway is the tendency for improvements to be developed in fads. Innovations which evidence considerable improvement in certain ways are often pushed to an unjustifiable excess, or without judgment are applied to conditions which they were never intended to meet; so that many so-called improvements are really detrimental fads. It is in matters of this kind that the shop manager has most opportunity for a display of judgment—in which he can evidence his ability to recognize the relative importance of things. We are all aware of the uneconomical extremes to which the use of air has in many cases been devoted. And at present there are numerous instances observable where electricity is being applied to uses and services for which it is not nearly as well adapted as is some other form of power. It seems as if there are many who do not recognize that each form of power has its own particular field, in which field it is undoubtedly superior to other forms of power, but outside of which it, while possibly able to perform the work, is by no means the best for the purpose.—Railway and Engineering Review.

The Railway Age of August 31 has this to say:

For over two years experiments have been in progress with the compressed air motors on street car lines in New York City and in Chicago. The results of these trials are such as to arouse the greatest interest on the part of engineers, the traveling public and investors. The trials in Chicago have been made on the North Clark street lines of the Union Traction Company, where two motor cars, equipped with the Hardie motor, have been in constant service since May, 1899.

These cars were placed in the "owl" or night service after the cable stopped, and the results here, as in New York, constitute a remarkably strong argument in favor of the use of individual motors operated by compressed air for street car ervice. Altogether, aside from the question of expense of operation and maintenance, the question of flexibility of service, the freedom from the disadvantages arising from the overhead trolley and the underground cable, with the attendant discomfort and inconvenience arising from tearing up of streets, etc., seem to make the arguments in favor of the motor operated by compressed air practically unanswerable, and it is reaonable to expect that the predictions of

a largely growing use for traction equipment of this kind will be realized.

In Chicago during the severe winter of 1899-1900 traffic on the street car lines was materially impeded by snow and ice, but the compressed air motors continued to run on schedule time and were not on a single occasion stranded by the results of the storms. The motor cars are not only able to carrry passengers to the full limit of their seating capacity, but to haul in addition one or two trailers, handling a total of from 200 to 400 passengers at one time.

The managing director and chairman of the International Pneumatic Tool Co., Mr. O'Donnell, sailed for New York on the 22d inst.

Recently the Robb Engineering Co., Ltd., Amherst, N. S., has installed a hydraulic riveting plant, pneumatic chipping and caulking tools, and other labor and time-saving machinery, which enables this firm to compete in any market in the world, as shown by its frequent foreign shipments.

The Postmaster General has issued an order directing a general investigation as to the cost of construction, operation and utility of all pneumatic tube systems for transmission of mails. This investigation is designed to enable Congress to determine whether the pneumatic tube service should be owned, leased, extended or discontinued by the Government There is an appropriation of $10,000 for the investigation, which will be conducted in a few of the principal cities of the country, including probably New York Chicago, Boston, Philadelphia, St. Louis, San Francisco and New Orleans.

Messrs. Wm. Beardmore & Co., owners and operators of the Parkhead Forge, at Glasgow, Scotland, have recently installed a new system of mechanical stoking and clinker cleaning grate bars for their large boiler plant, consisting of fifteen Babcock & Wilcox and eight Lancashire boilers.

The mechanical stoking is done in a very ingenious way, and the grate bars are set and constructed in a different manner as has generally been done up to this time.

The rear end of grate bars is 3 inches higher than the front end. They are hollow, perforated or slotted on top, according to the fuel used, and supplied with Compressed Air, which not only adds to the draught, but also disengages the clinkers. Each grate bar is about 4 inches wide, and has a back and forward motion given by a revolving cam, the motion being such as to carry the clinkers gradually towards the back end of the furnace and dropping them into a chamber from which they are drawn once a day. This dispenses entirely with stoking and slicing and adds greatly to the effectiveness of the combustible, and avoids loss of heat due to opening of fire doors for stoking, slicing or raking.

This is an entirely novel use for Compressed Air in connection with forced draught for boilers, and we are informed that this new method, which is of the Bennis patent, is very successful.

It is reported that a novel pneumatic riveter has been devised by Herman H. Prange of Akron, O., and it is thought to be a very practical machine.

The Standard Pneumatic Tool Company have just appointed Mr. F. A. Barbey representative for the New England States, and have opened offices at 185 Summer street, Boston, Mass.

Large clothes sometimes cover small men.

A man may have a straight mind and yet a crooked heart.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz., all communications should be written on one side of the paper only; they should be short and to the point.

Castillejos, P. I., July 13, 1900.

Compressed Air, 26 Cortlandt st., New York.

Gentlemen: I take this opportunity of informing the public of a method that I have devised by which compressed air may be used extensively and for the same purposes that steam is now employed.

What the method is I will not say, but should the method be adopted, it will be possible to start a train from Boston and run it into San Francisco without stopping, excepting in the case of a break; also, it

would be possible for a ship to make a voyage around the world in the same way.

I should be glad to correspond with any railroad or steamboat officials or anyone interested in such. I hope you will accord me space in your magazine, Compressed Air, for the publication of this short letter. Respectfully,

WILLIAM F. BLAKENEY,
Company K, Twenty-fifth Infantry,
Manila, P. I

PATENTS GRANTED AUGUST, 1900.

Specially prepared for COMPRESSED AIR.

655,285.—AIR-PURIFYING APPARATUS. Richard H. Thomas, Chicago, Ill. Filed April 20, 1900. Serial No. 13,654.

An air-purifier comprising a casing adapted for the passage of air therethrough, a screen disposed transversely of the casing, water-supply pipes disposed in the casing at opposite sides thereof and having discharge-nozzles disposed to discharge in opposite directions and in parallel planes, and baffle-plates in the rear of the screen.

655,541.—MARINE AIR-POWER APPARATUS. August M. Becker, New York, N. Y., assignor of one-half to Martin Steinthal, same place. Filed April 3, 1900. Serial No. 11,301.

A marine air-compressing apparatus the same comprising the combination of a set of air chambers arranged at different levels and open at the bottom only so that the water may enter and leave such air chambers through the bottom, and communicating with the outer air through the bottom only, a compressed-air reservoir and pipe connections leading from the upper part of each of said air chambers to said reservoir, said pipe connections being provided with valves for preventng a backflow of air from the said reservoir to the said air chambers, substantially as and for the purpose set forth.

655,654.—AIR-BRAKE FOR AUTOMOBILES. Irving L. Hammond, Lewiston, Me. Filed April 30, 1900. Serial No. 14,934.

An air-brake, the combination with the reservoir and a rotable cam, of a pump connected with the reservoir, a piston for the pump having a rod lying normally in the path of rotation of the cam for operation thereby, said rod having notches therein, a pivoted latch for engagement with the notches of the rod to hold it retracted from its operative relation to the cam, a cylinder connected with the reservoir and provided with a piston, and a rod for the piston disposed for engagement with the latch to move the latter to engage a notch of the pump-rod.

655,997.—AUTOMATIC AIR-PIPE COUPLING. John W. Spurlock, Ty Ty, Ga., assignor of one-half to Eliza C. Tift, Tifton, Ga. Filed March 21, 1900. Serial No. 9,562.

An automatic air-pipe coupling, comprising two members, and spring-rod for supporting the same from the cars, the spring-rods being formed with coils between their ends and arranged for holding the members under the tension of the springs, when coupled, substantially as described.

An automatic air-pipe coupling, comprising two members having longitudinally-extending coupling-faces, guides for guiding one coupling-face upon the other and for limiting the movement of the members in one direction when coupling the members, and spring-rods for supporting the members and for holding the same under tension when in a coupled position, the spring-rod being formed with coils between their ends.

An automatic air-pipe coupling, having a member comprising a body with a longitudinally-extending coupling-face, a pipe extending transversely from the said member for connection with the coupling-hose, a gasket set in the said face and projecting therefrom, with the inner end of the gasket in communication with the pipe, and a forked guide carried by the said body, said guide projecting from one edge of the body and extending with its prongs in front of the coupling-face of the body.

656,147.—HYDRAULIC AIR-COMPRESSOR. John W. Van Brocklin, Seattle, Wash., assignor of one-sixteenth to Russell L. Dunn, San Francisco, Cal. Filed Aug. 9, 1898. Serial No. 688,171.

Combination with two air-compression cylinders of two water-pipes connected therewith, a cylindrical inlet-valve and cylindrical outlet-valve for each of these pipes, a rod connected to each of these valves, a rotating wheel carrying cams, intervening parts arranged to be operated by the said cams and lifting the said valves and adjusting-nuts and springs for regulating this action.

In hydraulic air-compressors, the combination of a wheel and cams carried thereby with sliding bars having projections engaged by the said cams, the racks moving with said cams, the intervening cogged idler engaging the said racks to insure reciprocal motion, the water-inlet valve and water-outlet valve operated by the said slides and the adjusting-nuts and springs for regulating the action of the valves.

656,516.—AIR-BRAKE. Francis L. Clark, Pittsburg, Pa., assignor to the Westinghouse Air-Brake Company, same place. Filed May 23, 1899. Serial No. 717,974.

An air-brake apparatus, the combination, substantially as set forth, of a brake-cylinder adapted to be fixed vertically to the inclined end of a car-body, above the sills thereof, a bell-crank lever journaled horizontally below said cylinder and having its upper arm coupled to the piston-rod thereof, a double-armed equalizing-lever located below said cylinder, a link coupling the lower arm of the bell-crank lever to the equalizing-lever, a brake-applying lever coupled directly to the equalizing-lever, and a brake beam and shoes connected to the brake-applying lever.

An air-brake apparatus, the combination, substantially as set forth, of a brake-cylinder adapted to be fixed vertically to the inclined end of a car-body, above the sills thereof, a bell-crank lever journaled hori-

zontally below said cylinder and having its upper arm coupled to the piston-rod thereof, a double-armed equalizing-lever located below said cylinder, a link coupling the lower arm of the bell-crank lever to the equalizing-lever, a sheave journaled in said link, a hand-brake shaft journaled on the car-frame, a stop fixed to the car-frame, a chain passing around the sheave and connected to the hand-brake shaft and stop, a brake-applying lever coupled directly to the equalizing-lever, and a brake beam and shoes conected to the brake-applying lever.

656,572.—APPARATUS FOR RAISING WATER BY COMPRESSED AIR. Julius Petermann, Crimmitzschau, Germany. Filed April 17, 1900. Serial No. 13,269.

In combination in an apparatus for raising water, a water-chamber, a discharge-pipe for the water leading therefrom, air inlet and outlet pipes, a combined inlet and outlet valve having a piston and controlling the passage of the air through both of said pipes, a second valve for controlling the position of the valve, an air-pipe leading to the space between the piston of the valve and the valve, an outlet leading from said space and controlled by the valve, said outlet connecting with the outlet-pipe, and a pipe connecting the space between the air-inlet valve and the air-outlet pipe with the water-chamber.

656,823.—AIR OR GAS ENGINE. Robert H. Little, Chicago, Ill., assignor of one-half to Simon W. Straus, same place. Filed Oct. 9, 1899. Serial No. 732,992.

An apparatus of the character described, comprising the combination of two compartments for holding fluid under pressure, a chamber also for holding fluid under pressure intermediate said compartments and provided with ports opening directly into the latter, channels for the admission and exhaust of air or gas under pressure to and from each of said compartments, to force the liquid therein back and forth between said compartments and said intermediate chamber, a pressure-motor in said intermediate chamber to receive the force of the liquid as it is expelled from either of said compartments through said intermediate chamber and into the other of said compartments, suitable valve mechanism for controlling admission or exhaust of air or gas to and from each of said compartments, and valves for the ports between said compartments and said intermediate chamber for controlling the flow of liquid between said compartments and chamber.

657,025.—AIR-COMPRESSOR. E. Hurn, Trowbridge, England, assignor to Joseph Poynton Haden, same place. Filed June 1, 1900. Serial No. 18,760.

In air-compressors in which the power is automatically thrown out of gear when the pressure in the receiver reaches a predetermined magnitude, the combination with the delivery pipes leading from the compressor to the receiver of a relief-valve in the delivery-pipe connected to the automatic throwing-out mechanism to be operated thereby and a check-valve at the end of the delivery-pipe; in which the power is automatically thrown out of gear by a controlling-cylinder communicating with the receiver and having a loaded piston, the combination with the delivery-pipes and check-valve, a relief-valve, valve-rod, two levers, three cylinders, loaded piston and rod and pipe.

The Air Brake

OVER

1,250,000

IN USE.

The
Westinghouse Air Brake Co.,
Pittsburgh, Pa.

21D

UNITED STATES COMMISSION TO THE PARIS EXPOSITION OF 1900.

PARIS OFFICES, Aug. 31st, 1900.

GRAND PRIX FOR "COMPRESSED AIR."

I have the honor to inform you that in accordance with the official announcement of awards at the Paris Exposition of 1900, a Grand Prize was bestowed upon the exhibit of United States journals, publications and periodicals, and that you are therefore entitled to use this award of Grand Prize

Respectfully yours,
A. S. CAPEHART,
Director of Liberal Arts and Chemical Industries.

The New System
OF EDUCATION

Mechanical Engineering

Electrical, Civil and Mining Engineering; Drawing; Surveying; Chemistry; Plumbing; Architecture; Bookkeeping; Shorthand; English Branches

TAUGHT BY MAIL.
Over 50 Courses.

We have helped thousands to better positions and salaries. Send for free circulars, stating the subject in which you are interested.

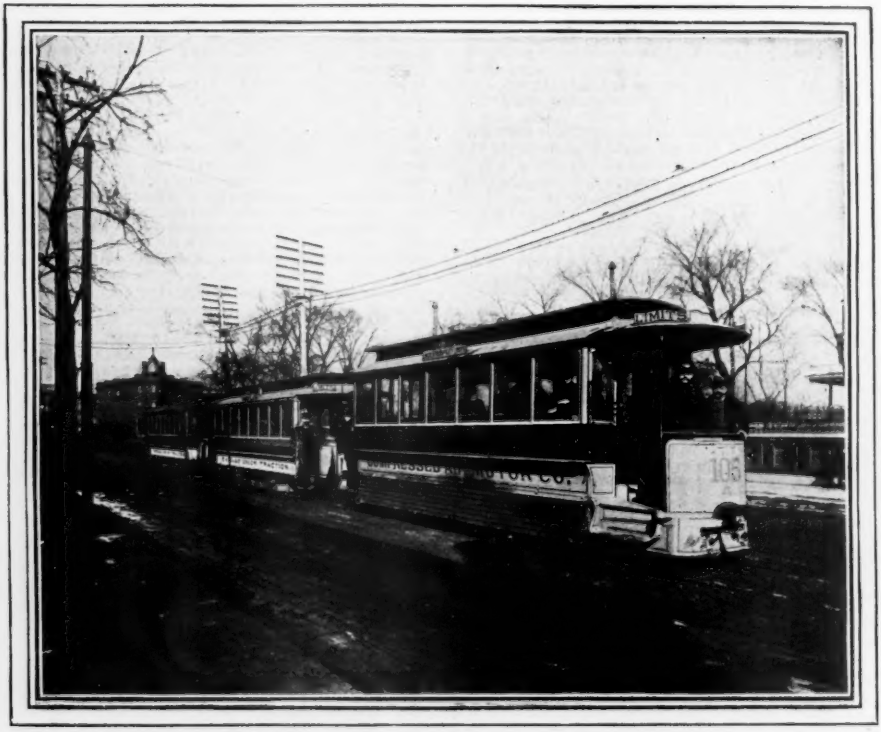
THE INTERNATIONAL CORRESPONDENCE SCHOOLS,
Box 1182, Scranton, Pa.

COMPRESSED AIR COMPANY.

Controlling the American Air Power Company of New York
and the Compressed Air Motor Company of Illinois.

COMPRESSED AIR MOTORS

FOR STREET, SUBURBAN AND ELEVATED RAILWAYS.



The above cut is of a 28 foot Compressed Air Motor Car hauling two trail cars in Chicago.

COMPRESSED AIR CO.,

621 Broadway, - - NEW YORK.
1032 Monadnock Block, - CHICAGO, ILL.

COMPRESSED AIR COMPANY.

Controlling the American Air Power Company of New York and the Compressed Air Motor Company of Illinois.

COMPRESSED AIR MOTORS

FOR STREET, SUBURBAN AND ELEVATED RAILWAYS.

COMPRESSED AIR MOTORS ARE

Independent, under quick control, noiseless, of high efficiency, free from danger and all objectionable features. The most economical system in cost of installation, operation and maintenance ever offered to street and other railways. Thoroughly tested, both Winter and Summer, and endorsed by prominent engineers.

Cars, in size and appearance, are the same as electric or cable cars, the floor being no higher from rail. No paying space occupied by the air storage or mechanism, all being placed under the car floor.

RUN AT ANY SPEED DESIRED.
OVERCOME GRADES AND SHARP CURVES EASILY.
EQUIPPED WITH NOISELESS AIR BRAKES.

Can be recharged with air in less than two minutes, and constructed to run any desired distance. Motors and entire load spring supported. Cars can be introduced one at a time on the track of any railway, steam, electric, cable or horse. Cars of this type performed a daily service of 81½ miles each upon 125th Street, New York City, for one complete year, during which time they ran 32,159 miles, and carried 188,854 cash fares, and are now, and have been since May 30, 1899, in operation on North Clark Street, Chicago.

The Metropolitan Street Railway Company, on 28th and 29th Streets in New York City, during the last three months of 1898 operated the line by horse power, and during the corresponding period of 1899 by air, with the following comparative results:

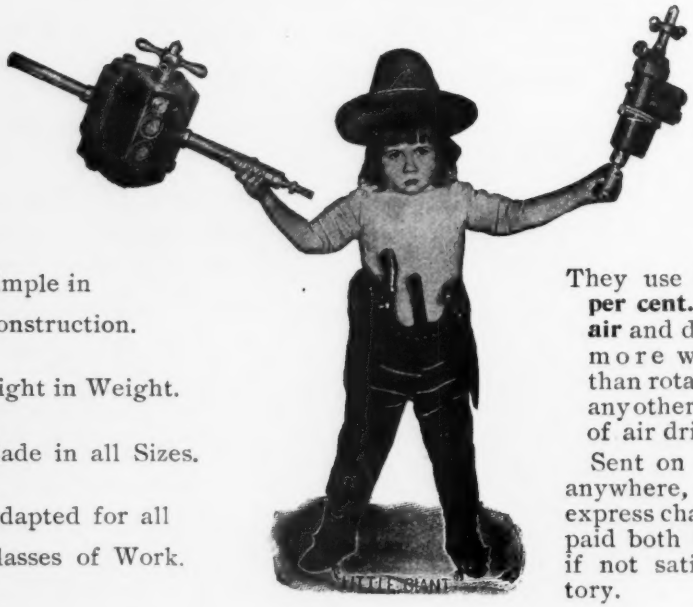
	1898 (horse)	1899 (air)
Number of cars employed, ...	16	15
Car mileage per day, ...	1310	1530
Number of passengers carried, . . .	1,183,170	1,681,580

In Chicago, where air cars were introduced for night service in place of horse cars, it has resulted in more than doubling the number of passengers carried during those hours.

The Only Piston Air Drills Made

THAT HAVE DOUBLE-BALANCED PISTON VALVES THAT CUT-OFF AT 5/8 OF THE FULL STROKE ARE THE

"LITTLE GIANT."



Simple in Construction.

Light in Weight.

Made in all Sizes.

Adapted for all Classes of Work.

They use **fifty per cent. less air** and do far more work than rotary or any other type of air drill.

Sent on trial anywhere, and express charges paid both ways if not satisfactory.

STANDARD PNEUMATIC TOOL COMPANY,

Manufacturers of Pneumatic Drills, Hammers, Flue Rolling, Reaming, Tapping and Boring Machines, Blow-off Cocks, and all kinds of Air Tools and Appliances,

MARQUETTE BLDG., CHICAGO.

141 BROADWAY, NEW YORK.

CHAS. G. ECKSTEIN,

MECHANICAL ENGINEER,

Berlin, C., Germany. Spandauerstrasse 16-17.

Makes it a specialty to sell

Pneumatic Tools and Appliances

and

Compressed Air Machinery in General,

in Europe.

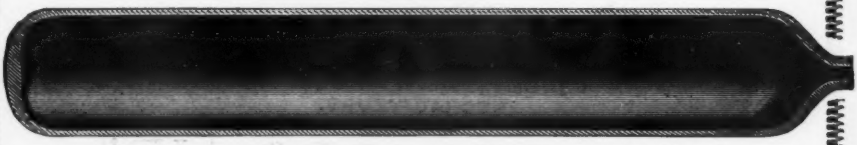
American Manufacturers of

FIRST CLASS TOOLS AND MACHINERY

in above line, seeking an effective representation abroad, are respectfully invited to correspond with the New York Office, 249 Centre Street.

Seamless Rolled Steel Tubes

FOR GASES, COMPRESSED AIR, ETC.,
UNDER HIGH PRESSURE.



In lengths up to 24 feet.

Manufactured in Germany after the famous *"Mannesmann Process."*

Tested and approved by the highest authorities and Governments of Europe and America.
Each Tube is carefully tested, and a Government Test Certificate is furnished with same.

Representative:

Chas. G. Eckstein,

249 Centre Street, New York.

H. GLAENZER & PERREAUD,

Mechanical Engineers,

1, Avenue de la République,
& 61, Rue de Malte.

TELEGRAMS:
"BLAKENILES,"
"PARIS."

PARIS.
(FRANCE.)

A. B. C. 4TH ED.
LIEBER'S
OR A1'S CODES.

INGÉNIEURS-CONSEILS POUR INSTALLATIONS D'AIR COMPRIMÉ &

AGENTS EXCLUSIFS DE

Chicago Pneumatic Tool Co.,

OUTILS PNEUMATIQUES,

Curtis & Co. Mfg. Co.,

Geo. F. Blake Mfg. Co.,

COMPRESSEURS D'AIR AUTOMATIQUES À VAPEUR & À COURROIE
VÉRINS PNEUMATIQUES.

Merrill Pneumatic Pump Co.,

POMPES PNEUMATIQUES.

Wheeler Condenser.

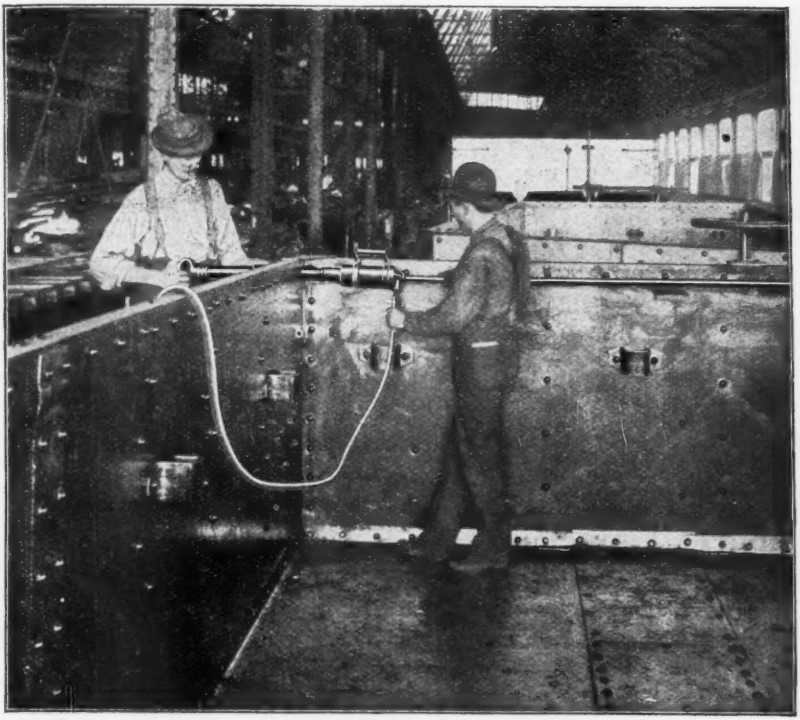
CONDENSEURS PAR SURFACE.
RECHAUFFEURS.

"COMPRESSED AIR"

REVUE MENSUELLE DES APPLICATIONS DE L'AIR COMPRIME.
ABONNEMENT: 8 FRANCS PAR AN.

Messrs. H. GLAENZER & PERREAUD have been the leading introducers of compressed air machinery in France. They will receive with pleasure correspondence from American manufacturers of compressed air machinery, tools, and supplies.

Chicago Pneumatic Tool Co.



Pneumatic Holder-on and Long Stroke Hammer driving rivets on steel cars. The most powerful Pneumatic Hammer made, weighs 14 pounds, and will drive 1¼ inch rivets.

PNEUMATIC .... TOOLS

FOR ALL PURPOSES

Sent on trial subject to approval.
Send for book and read what large Railroads, Shipyards and Manufacturers say of our Tools.

New York Offices: 95 LIBERTY STREET, N. Y.

General Offices: MONADNOCK BLOCK, CHICAGO.

We're making a Specialty of

Filling the foundryman's wants. We're making a specialty of doing this neatly, quickly, and in a way that puts money in his pocket.

We don't undertake any job belonging to the iceman. We don't know anything about cutlery. We couldn't write a respectable looking article about lemon squeezers. Our ideas are very crude regarding fruit jars. Our experience is very limited in setting saws.

We leave all those lines to the journals that "covereth the whole earth."

We don't know it all and we don't try to do it all.

We have "boiled down" and concentrated all our "know how" to the formerly neglected foundry business.

We dish up every month the most appetizing nourishment for all kinds of foundries. Nothing but foundries mind you.

Everyone has paid for his meal ticket too. Not a deadhead sits at our table. No "free soup" goes with us.

Let us sandwich in an advertisement of the stuff you want the foundries to buy.

It will be masticated all right. The orders you will get thereafter will show you that you have not advertised in vain.

THE FOUNDRY,

DETROIT, ∴ ∴ ∴ ∴ MICHIGAN.

CORNELL & UNDERHILL

Wrought and Cast Iron Pipe
Boiler Tubes
Artesian and Oil Well Casing
Iron and Brass Fittings
Valves and Cocks
Gate Valve and Hydrants
Freight, Mine and Dump Cars
Portable Track and Switches
Car Wheels of every description

13 GOLD STREET.

TELEPHONES, FRANKLIN 2932-2933. CABLE ADDRESS, "CUBE," NEW YORK.

Janney, Steinmetz & Co.,

COLD DRAWN, HOT PRESSED AND FORGED

STEEL SHAPES AND SPECIALTIES

SEAMLESS COLD DRAWN STEEL SHELLS, CYLINDERS AND TANKS

For Air, Water, Steam, Gas, Soda, Ammonia or Fluids under Pressure and Explosives.

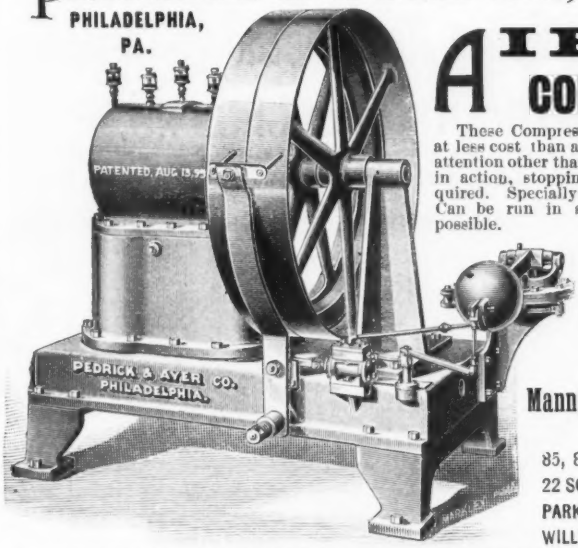
SEAMLESS STEEL TUBING, HEAVY SECTION TUBES, HYDRAULIC FORGINGS FOR CREAM SEPARATOR BOWLS, SEAMLESS STEEL TESTED TANKS OF SUNDRY DIAMETERS.

DREXEL BUILDING,

PHILADELPHIA.

PEDRICK & AYER CO.,

PHILADELPHIA, PA.



AIR COMPRESSORS

These Compressors will compress more air at less cost than any other make, requiring no attention other than oiling; entirely automatic in action, stopping and starting as air is required. Specially adapted for foundry use. Can be run in series; if so, no stoppage possible.

COMPRESSED AIR RIVETERS, HOISTS, CRANES AND OTHER TOOLS.

Send for Catalogue.

Manning, Maxwell & Moore,

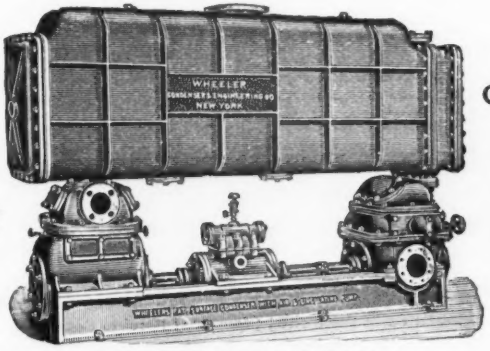
SOLE AGENTS,

85, 87, 89 LIBERTY ST., N. Y.
22 SO. CANAL ST., CHICAGO, ILL.
PARK BLDG., PITTSBURGH, PA.
WILLIAMSON BLDG., CLEVELAND, O.

WHEELER CONDENSER & ENGINEERING CO.

NEW YORK.

For MARINE and STATIONARY SERVICE.



SURFACE CONDENSERS Mounted on Combined Air and Circulating Pumps.

PROPRIETORS AND MANUFACTURERS OF

WHEELER STANDARD SURFACE CONDENSER; WHEELER ADMIRALTY SURFACE CONDENSER; WHEELER LIGHTHALL SURFACE CONDENSER; VOLZ PATENT SURFACE CONDENSER AND FEED WATER HEATER; EDMISTON PATENT FEED WATER FILTER.

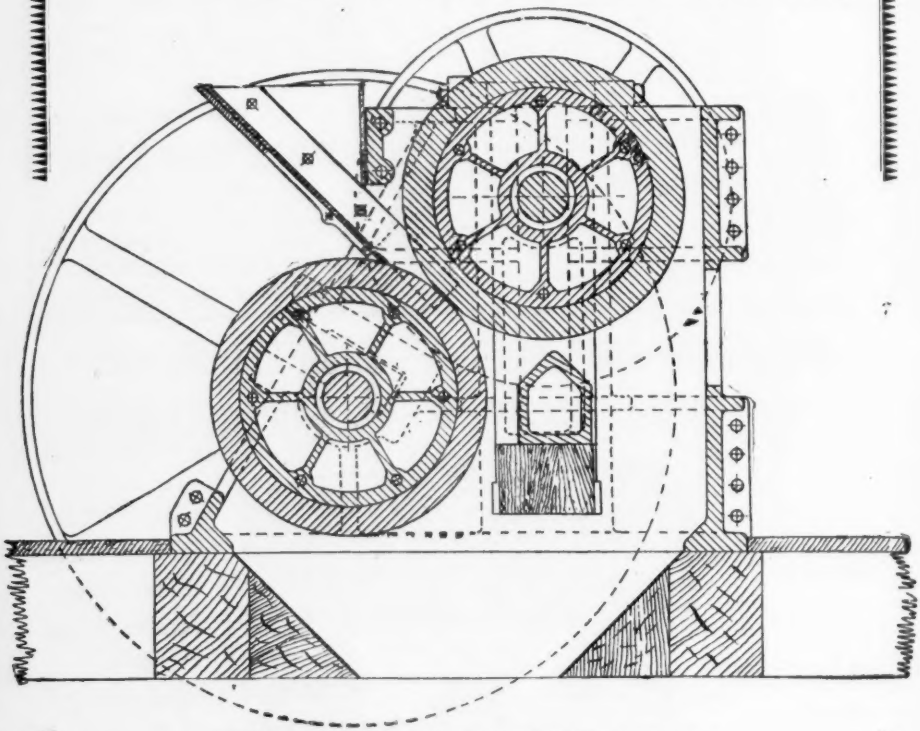
WHEELER'S PATENT FEED WATER HEATER.

The Stearns-Roger Manufacturing Company,

CONSTRUCTING ENGINEERS.

Chlorination Mills, Electric Plants

Compressed Air Plants of any capacity.



ROGER'S IMPROVED CRUSHING ROLLS.

Patented in the United States and Foreign Countries.

"These Rolls have been running very satisfactorily and appear to us to be unquestionably the best type of roll yet devised. General Manager,
MOLLIE GIBSON & A. J. MILLS, Aspen, Colorado."

Manufacturers of all classes of Machinery for Mining and Metallurgical requirements.

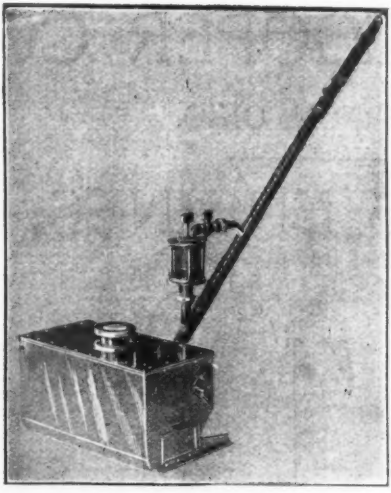
MAIN OFFICE, 1718-24 CALIFORNIA STREET, DENVER, COLO., U. S. A.

GENERAL COMPRESSED AIR HOUSE CLEANING COMPANY.

INCORPORATED CAPITAL $100,000.

LONG DISTANCE 'PHONE MAIN 2552.

Offices: Lincoln Trust Building, St. Louis, Mo.



HOUSE RENOVATOR.

Correspondence is invited from parties desiring to engage in cleaning houses, including carpets, rugs, draperies, bedding and upholstered furniture by the dustless method.

Exclusive City Rights For Sale.

By our system houses are thoroughly cleaned and disinfected with compressed air.

Recommended by the Medical Profession.

Revolution in House Cleaning.

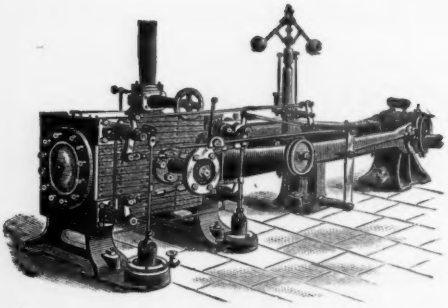
This device thoroughly renovates the carpets, removes and collects all of the dirt and impurities that the carpet contains.

This method is protected by Letters Patent, others pending.

For further information, address

GENERAL COMPRESSED AIR HOUSE CLEANING COMPANY.

CONTRACTORS AND ENGINEERS FOR COMPLETE RENOVATING PLANTS FOR HOTELS, RESIDENCES, HOSPITALS AND PUBLIC INSTITUTIONS.



Established
1833.

The
C. & G. COOPER CO.

MT. VERNON, OHIO.

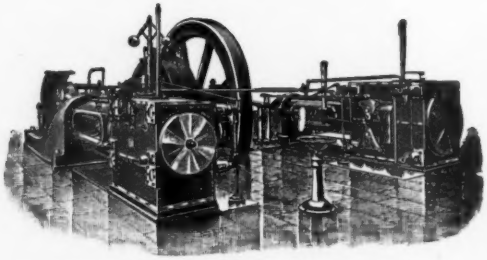
CORLISS ENGINES.

COMPOUND.

TRIPLE EXPANSION.

SINGLE CYLINDER.

Of all sizes up to 3,000 Horse-power.



— FOR —

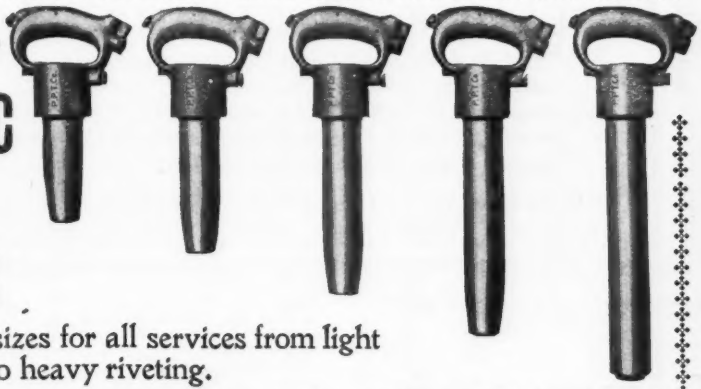
FACTORIES, RAILWAYS, ELECTRIC LIGHTING, ROLLING MILLS, AND ALL KINDS OF MANUFACTURING.

CORRESPONDENCE SOLICITED.

HOME OFFICE: MT. VERNON, OHIO.

NEW YORK: Room 1022 Havemeyer Building, F. W. IREDELL, Mgr.

PNEU-MATIC HAM-MERS

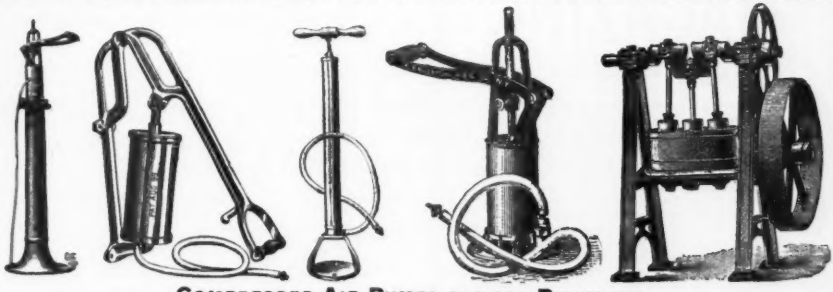


All sizes for all services from light calking to heavy riveting.

These hammers have the simplest valves yet designed and hence the least likely to get out of order. They cannot break or become inoperative through slight wear. They are fully guaranteed against cost for repairs for one year.

PHILADELPHIA PNEUMATIC TOOL CO.,

NEW YORK, SINGER BUILDING. PHILADELPHIA, STEPHEN GIRARD BUILDING. PITTSBURGH, WOOD & WATER STS.



COMPRESSED AIR PUMPS FOR ALL PURPOSES.

GLEASON-PETERS AIR PUMP CO., 20 West Houston Street, N. Y.

BULLOCK DIAMOND DRILLS

They Remove Solid Cores For Prospecting.
Operated By COMPRESSED AIR, STEAM and ELECTRICITY.
Also by HAND POWER, HORSE POWER and GAS ENGINE.
19 STYLES and SIZES—SURFACE and UNDERGROUND.
Capacity from 350 feet to 6,500 feet.

If you are interested in prospecting, send for our No. 33 Catalogue.

M. C. BULLOCK MFG. CO., - - CHICAGO, ILL.

Compressed Air.

Practical information upon Air-Compression and the Transmission and Application of Compressed Air.

By FRANK RICHARDS. 12mo, cloth, $1.50

John Wiley & Sons, New York.

AIR BRUSH FOR ART WORK.

We are making and selling the best Art Tool in use. Applies color by jet of air, enabling the artist to do better work and save time. No studio complete without it. Circulars free.
Address, AIR BRUSH MFG. CO. 60 Nassau St., Rockford, Ill., U.S.A.

Used by the Officers of all Railroads

THE POCKET LIST OF RAILROAD OFFICIALS
(ISSUED QUARTERLY)
Subscription Price, **$1.00 per annum.**
Advertising rates on application.

THE OFFICIAL RAILWAY EQUIPMENT REGISTER
(ISSUED MONTHLY)
Descriptive of freight and passenger cars of the Railways and Private Companies in the United States, Canada and Mexico.
Subscription Price, **$5.00 per annum.** Single copies, $1.00.

THE RAILWAY EQUIPMENT & PUBLICATION CO.
24 Park Place, New York.

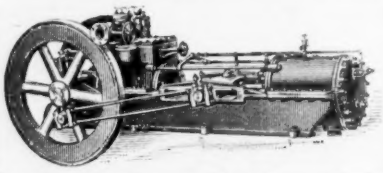
THE ENGINEERING MAGAZINE

AN INDUSTRIAL REVIEW

"The Engineering Magazine has been aptly described as "*The Century* of the industrial world and the *Review of Reviews* to engineering literature—the two in one." Its leading articles treat the subjects uppermost in importance in industrial affairs. Its contributors include the foremost men of our times. It gives each month an exhaustive Review and Index to the world-wide range of technical literature—American, English, French, and German. It is read in every nook and corner of the civilized world. It is founded upon the idea of meeting the requirements of the busy and brainy men who manage, think, and plan for the engineering, architectural, electrical, railroad, mining, and mechanical industries. It has a larger bona-fide circulation among such men than has ever been attained by an engineering journal in all the history of industrial literature. It is priceless to the active man who needs to keep in touch with current developments. Its every page carries a living interest for intelligent readers who are in any way concerned with modern industrial enterprises. Its subscribers are its warmest advocates and the Magazine itself is its best solicitor. *Sample copy free.*

30 Cents a Number; $3.00 a Year.

THE ENGINEERING MAGAZINE,
120-122 Liberty St., New-York, U. S. A.



McKiernan Drill Co.,

120 LIBERTY STREET,
NEW YORK,

MANUFACTURERS OF

Rock Drills, Etc.

Air Compressors

Various Types. Special Designs. Suitable for all Dynamic Purposes.

SOLE AGENTS FOR THE

Kennedy Patent Air Lift.

INGERSOLL-SERGEANT

STYLES AND SIZES. Over 300 sizes and over 40 styles, and an unlimited variety of combinations in Steam, Belt, Electric, Gear, Water Power, or Gasoline Driven Air Compressors.

PRESSURES. Standard types giving a minimum pressure of 5 pounds to the square inch and from that on up progressively to 3,000 pounds and more to the square inch.

WORKMANSHIP AND MATERIAL. The Best; It comes of long experience as to the conditions, and demands of air compression. No other method tolerated by us or suited to our trade.

CONSTRUCTION. Every detail follows in care and accuracy the practice of manufacturing concerns that build machinery to perpetuate reputations gained by making every improvement known to the art.

AIR COMPRESSORS

CONDITIONS. A reasonable amount of attention given by experts to every machine sold covering a period of time long enough to convince the buyer that every effort is made to supply him with a substantial machine.

DESIGNS. All machines designed with pleasing architectural features, giving attention to floor space, insuring rigidity and strength, and consequent comparison with other lines of high-class machinery.

LITERATURE. The rapid adoption of compressed air and the number of uses to which it is applied are shown in catalogues and booklets sent free on application.

THE INGERSOLL-SERGEANT DRILL CO.

MANUFACTURERS OF

Air Compressors, Rock Drills, Coal Cutters, Air Lift Pumps, Stone Channeling Machines (Steam or Air), etc.

OFFICES:

CHICAGO, 84 Van Buren Street.
CLEVELAND, Ohio, 26 South Water Street.
BOSTON, Mass., 77 Oliver Street.
HOUSTON, Tex., Kiam Building.
DENVER, Col., 227 South Temple Street.
SAN FRANCISCO, Cal., 21 Fremont Street.
BIRMINGHAM, Ala., 18 South 20th Street.
St. LOUIS, Mo., Fullerton Building.
BUTTE, Mont., 300 Main Street.
St. PAUL, Minn., 4th and Wacouta Streets.
SEATTLE, Wash., 310 1st Ave., South.
MONTREAL, Can., 299 St. James Street.
MEXICO CITY, San Juan Letran 13.
LONDON, Eng., 114a Queen Victoria Street.
" " 114 Leadenhall Street.
SYDNEY, Australia, 187 Clarence Street.
KALGOORLIE, West Australia.
JOHANNESBURG, So. Africa, Box 1809.
VALPARAISO, Chili.
YOKOHAMA, Japan, No. 22.

26 CORTLANDT ST., NEW YORK.

FOR ALL

AIR COMPRESSORS.

AIR USES

SEND FOR CATALOGUE

NEW YORK AIR COMPRESSOR CO.

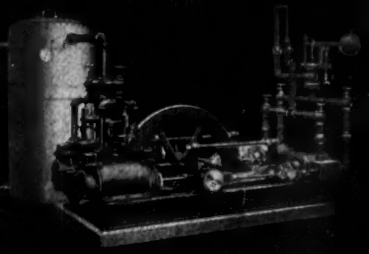
95 LIBERTY ST. NEW YORK, U.S.A.

"Embodying the Latest and Best Practice."

"Fittingly Representative of an Age of Progress."

Air Compressors

For Operating
PNEUMATIC TOOLS,
HOISTS, ROCK DRILLS
and every other application of Compressed Air.



CLAYTON AIR LIFT SYSTEM
BREWERS AIR PUMPS

Clayton Steam Duplex Type.

CLAYTON AIR COMPRESSOR WORKS,

Catalogue.

26 CORTLANDT ST., NEW YORK.